A Hollow Building Compendium for Amateur Rodmakers (and the Cressy Cane Hollowing Experiment) by Chris Fiddes

Disclaimer

I am an amateur hobbyist maker of limited experience and ability whose intention here is to give fellow amateur makers an overview and starting point when hollowing bamboo fly rods.

This is a compilation of available materials , by no means complete , possibly erroneous or subject to interpretation as I have no engineering , mathematics or design background … I have tried to only include explicit information where it is freely available online with references and recognition given .

A Hex configuration for trout rods is mostly discussed here … there is even less data about the effects of hollowing of Penta and Quad , or of novel configurations , generalisations should however hold true .

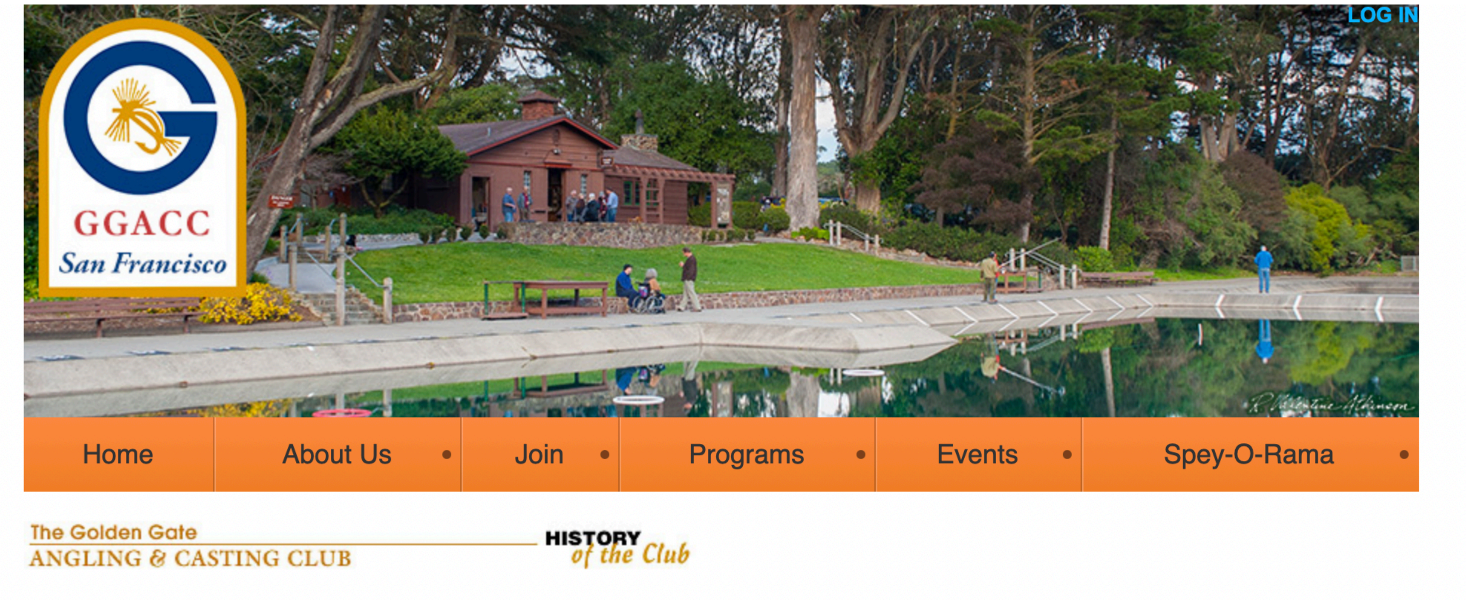
Thanks must go to all Bamboo afficianados who have contributed to online discussions and gatherings , all the makers who responded to my emails , especially to Nick Taransky whose rod making class and generous replies to all my queries taught me so much …many amateur makers like myself are heavily indebted to you all … any errors in what follows are of course my own and hopefully just another false cast in the stream of knowledge

Sections

1.Some History

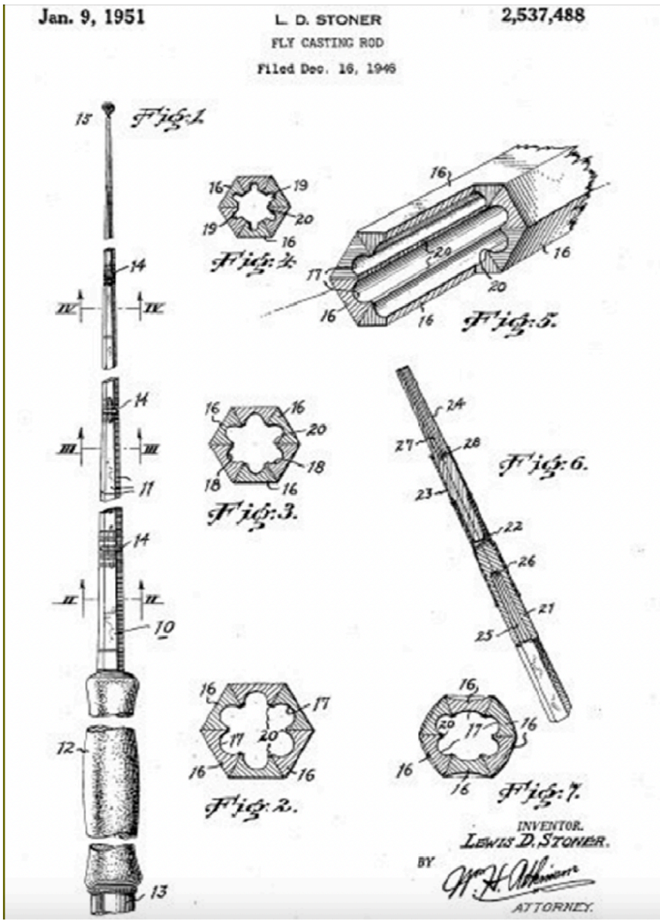
While Hollowing undoubtedly had occurred as an experiment by makers almost as soon as multiple strip construction methods started , most agree its takeoff as a method of rodbuilding was in the 1930s on the West Coast of America

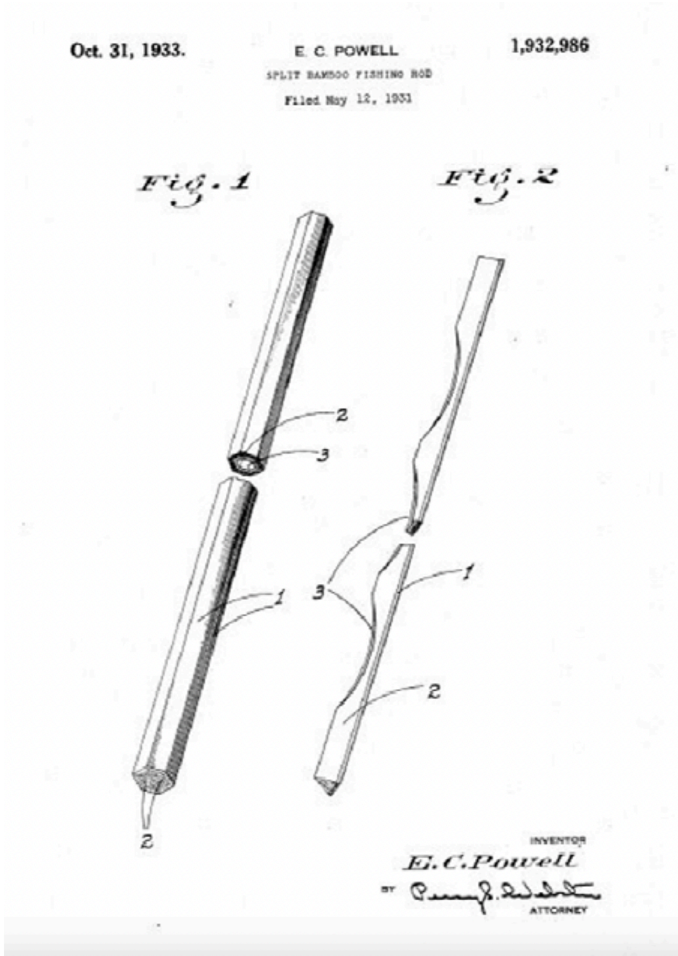
i) Californian Casting Competitions in the 1930s where rod weight restrictions led makers to experiment with hollowing



“The hollow fluted bamboo rods of R.L. Winston Rod Co. and the cedar center hollow construction of E.C. Powell Rod Co. - also designed by Club members - produced astounding lightness and power”

ii) USA Patents followed soon after of Fluting Method by Winston 1931, Hollow Hex with Internal Support Structure by CM Anderson 1932 , and Scallop & Dam method by EC Powell 1933


Jan. 9, 1951
L. D. STONER
2,537,488
FLY CASTING ROD
Filed Dec. 16, 1946
INVENTOR.
LEWIS D. STONER.
BY
ATTORNEY.


Oct. 31, 1933.
E. C. POWELL
1,932,986
SPLIT BAMBOO FISHING ROD
Filed May 12, 1931
Fig. 1
Fig. 2
INVENTOR
E.C.Powell
ATTORNEY

a. Winston


R.L.Winston Rod Co.
475 THIRD STREET
SAN FRANCISCO, CALIFORNIA 94107

R. L. WINSTON'S GUARANTEE

We build only one quality rod, the very best that the hands of skilled craftsmen can produce. In addition to careful planning and many years of experience, it takes up to 17 hours of meticulous hand labor to complete a fluted hollow, split bamboo Winston Rod. Infinite care and attention are given to the smallest details. We guarantee every bamboo or fiber glass rod we sell to be structurally perfect in every way.

We do not, however, guarantee our bamboo rods against a slight off-set or fishing curve. This condition may occur in any fine bamboo rod. It is not a sign of structural weakness, and in no way detracts from the rod's casting ability or fishing life.

Because of the many man hours of hand work that we devote to our rods, we feel personally involved with each one of them. We want to know that they are in competent hands and doing the job for which they were designed. If any problem ever arises with any of our rods, please let us know!

age until we have a need for it, so our supply of the highest quality cane is assured for many years.

Again talking of rod building, the cane pole is split along the grain by hand and the nodes on each of the strips are sanded smooth by hand. Each and every strip is rigidly inspected, inch by inch, so that each is perfectly matched and the nodes staggered. These splines are then individually hand drawn through high speed, matched carboloy cutters of our own design. This operation is repeated again and again, using our own taper patterns, until the exact size we want is reached. In this cutting, we work to a tolerance of 1/1000 of an inch. The fluted hollowing of the strips for butts is performed in the same careful manner; every one of the 12 strips that will be glued together to make a butt and a tip is inspected dozens of times before the all-important gluing.

In the gluing operation, the six strips of a section are put together by hand, and the nodes checked so that no two are ever side by side. Water-proof glue of enormous strength is then applied to the inner surfaces and the section passed through our special pressure wrapping machine. The arms of this machine wind on heavy thread under adjusted pressure in two directions at the same time. The section comes through the machine tightly bonded and perfectly straight. The glued sections are then allowed to dry until needed. When the thread is removed, any section with the slighest defect is destroyed.

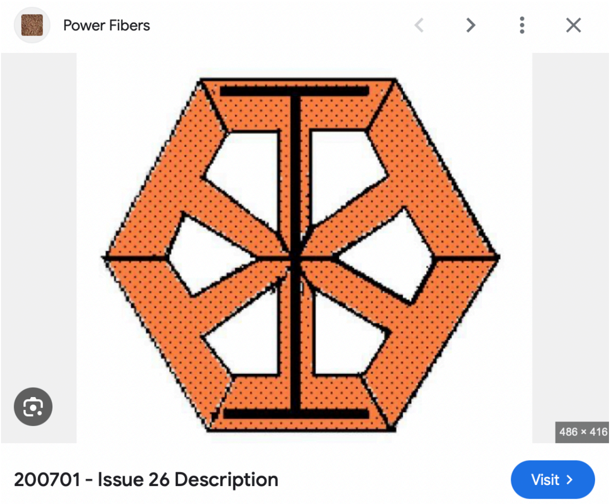
b. Powell

For more information see https://www.brandin-splitcane.com/ec-powell-book.html

Top three rod sections are from actual E.C. Powell rods, showing the outer bamboo, a 'solid cedar center' also with cross section, a cedar-core section also with hollow scallop, and the bottom section which is from a Brandin semi-hollow rod. These sections will be displayed in a sunken mount in the pull-out panel of the deluxe limited edition.

note - uncertain whether Andersons design went into production (see “Fly Rod with a Soul”) , it may have been too complex , appearing to have the internal support made separately to the strips

iii) Sigurd Vangen : 1940s Oslo Norway invented “ Magic Star” technique with internal support by cutout from the strip, for longer 9’ rods , see Planing Form newsletter Issue #98 March/ April 2006 article by Wolfram Schott on European Rods



iv) Post WWII in the UK Hardy get on board with Holokona & Hollolight , having also experimented in the 1930s with hollowed Salmon rods

From Schwieberts "TROUT" 1984: (Volume II p 1023-1027)

"Hollow split-bamboo rods originated in 1933, with the separate patents granted to Edwin Powell and Lew Stoner on the Pacific Coast. But Hardy introduced a remarkably different hollow rod using high-stress adhesives twenty-five years later - and James Hardy quickly used the new Hollolight and Hollokona designs to break the European distance records in 1959.”

Of note Hardy made these as Salmon rods also , as seen here on Edward Barders website

Barder Rod Co
Fine Handmade Fishing Rods

HOME ABOUT RODS STOCK BLOG CONTACT

Hardy Hollokona Salmon De-Luxe 9’6" #7 3-piece 2-top

This lovely single handed lightweight fly rod was made in 1963.

£500.00

“Designed for single handed use for salmon, sea trout and steelhead, the Salmon De-Luxe is a hollow-built split cane fly rod with a very smooth, contemporary action”

v) Pezon et Michel up to 1980s experimented with Hollowing & Ferrule placement without commercial success

vi) A few West Coast and Western makers who trained at the Powell and Winston rodshops continue making hollow bamboo rods in California and Montana respectively during the 70s ,80s & 90s while carbon rods became the standard in the fly fishing world

vii) 21st century hollowing renaissance driven by desire to compete with carbon by finding for bamboo either a longer or a stiffer rod , and the rise in popularity of Spey casting techniques where bamboo has some unique attributes

2. Some Modern Makers of repute

i) North American

- Winston - hollow fluting of butt section only
  - the only commercial rod maker that has always and still does offer hollow built bamboo rods
  - rodmakers who trained at Winston include the Boo Crew of Sweetgrass , Tom Morgan , Gary Howell & Wayne Maca

- Tom Morgan Rodsmiths - the famed Handmill also has hollow fluting and magic star attachments

- Mike Montagne - see interview with Reed Curry about development of hollow rectangular quad rods
  - exact hollowing method uncertain / proprietary , possibly a version of scallop & dam where the dams are only in opposing strips (the wider strips of a rectangular quad is my guess) or a type of alveolar/shark tooth method
  - famed for the rectangular quad

- Wayne Maca - extreme level hollowing right through the entire rod , see Beaverhead Rods website
  - 'sonic' and microscopic testing of bamboo and unique glue up method & glue materials which remain proprietary information (the sonic test was likely measuring speed of sound wave transmission to gauge power fibre density) , proprietary ferrules of carbon maybe hollowed also

- granted a patent in the early 2000s , now lapsed apparently

- Brandin , Wojincki , Hidy , Hanson , Reams , Raine , Vance , Thramer , Eugene Powell & others … note mostly West Coast makers … see California Flyfisher Magazine 2005 article by Tom Chandler here https://www.beaverheadrods.com/images/beavrds_pix/bamboorenaissance.pdf

- Two Handed Rod makers in British Columbia , Canada - Bob Clay , James Reid

- curiously Bob Clay helped develop the Morgan Hand Mill but uses the Scallop & Dam method for Riverwatch rods & in his Rodmaking videos attributes this to superior strength

ii) European

- Jocelyn D'Lespinay (France)
    - La Cane a Mouche published 1991 (in French)
    - Planing Form article 1995 has both external taper & hollowing method
    - "My Fly Rod" in English published 2010

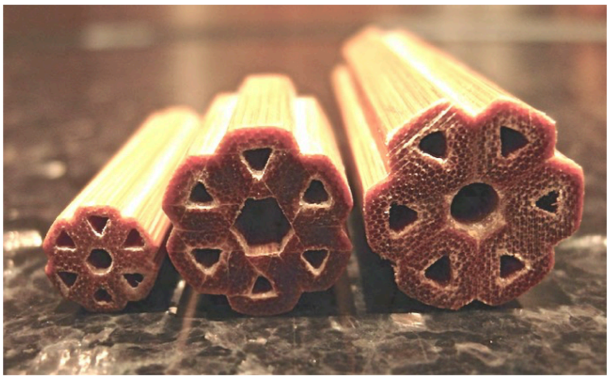
- Daniel Bremond (France)

- "Alvéolaire" method in France

- The Italian Casting School
    - use hollowing to achieve a stiffer faster rod action for a given rod length & weight

- Masimo Tirocchi (Italy) has an interesting discussion of hollowing , rod design and Italian casting available on his website as articles in Powerfibres , seen here https://www.massimotirocchi.com/the-philosophy-behind-the-taper-design/

- Kurt Zumbrunn (Switzerland) - claims invention of hollow tri-hex rods in early 2000s & other novel configurations (the Rose)



- Philip Sicher (Switzerland) - experiments in novel configurations & comparisons of different build methods including Evo6 (hollow TriHex) & Evo8 (hollow quad with corners squared)

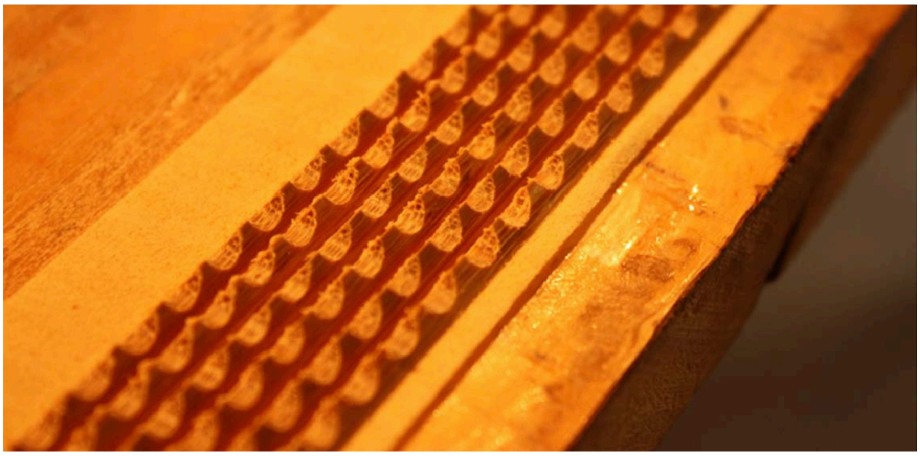
- very interesting 12 rod comparison of different build methods … Evo8 most popular geometry at Corbett Lake gathering , then Hollow Hex , then the rest

- Rolf Baginski (Germany) - cotton wool & polyurethane glue dam method (based on ski construction)

- reports of breakage via Tapani Salmi (Finland) in Powefibres 2019 issue no. 64 (also a nice discussion of hollowing triangular rods)

- Alberto Poratelli (Italy) - Shark Tooth method & Alveolar method

- IBRA Journal no.7 2011



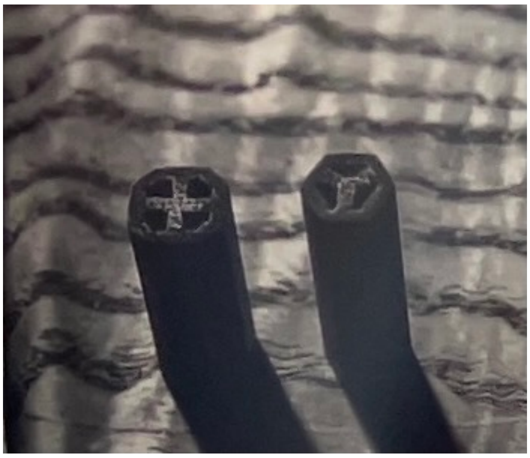
- it is interesting to consider the effect of the war years on European Fly Rods … would the Casting Club de France , Ritz casting method and Pezon et Michels inventiveness have seen a parallel development to the North Americans without the disruption ? Clearly some transatlantic cross pollination of ideas was occurring around the 1930s regarding hollowing methods and effects , we know many Anglers travelled widely and Ritz's time in America is well documented .Can we see these antecedents in modern European bamboo rods ? It is also worth noting Europe has always had and has maintained a long rod tradition for Atlantic Salmon as well as many regional indigenous fly fishing techniques

iii) Japanese

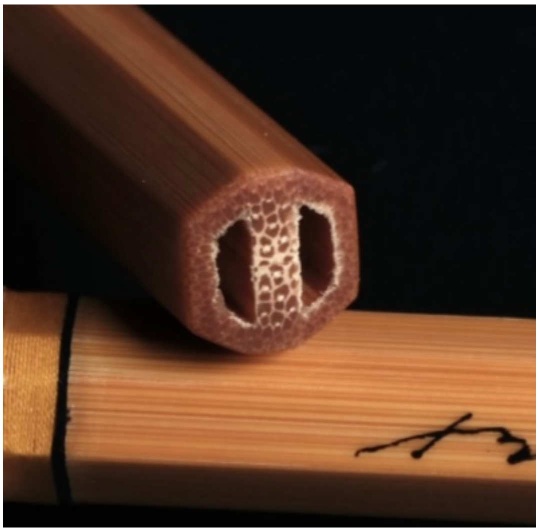
- Katsumi Harada - hollow Madake bamboo

- Kakuhiro Nonaka - hollow Hachiku bamboo

- Masaki Takemoto - T construction method seen below



- Hidenobu Kotake - A8 deformed Octagon



- 8 of 16 Japanese bamboo rod makers profiled by Yuki Bando in “Mostly Bamboo” employ a hollow built construction , Japanese makers appear to straddle both an international outlook and angling for indigenous species that requires lightweight rods for short distance casts

iv) Antipodean

- Nick Taransky - the search for the ideal NZ rod …the One Rod to Rule them All

- Mark Rampart - big rods for saltwater target species in Western Australia
  - Kiwicane 2024 presentation

Sunset on Brumbys Creek at Cressy , Tasmania

3. Methods of Hollowing

i). Fluting i.e hollow longitudinally along the rod

- usually continuous along the rod

a. Milling i.e Morgan Hand Mill , also plausible with CNC devices

https://tommorganrodsmiths.com/pages/toms-handmill-content?srsltid=AfmBOor-kXX7TwXh5DW1cAbwE-oY6hMAkqM64f1ITggdr1f6LSv37HC8

See TMR video on fluting with the Handmill here

https://tommorganrodsmiths.com/blogs/tmr-blog/watch-finish-planing-hollow-fluting-and-gluing-on-the-morgan-handmill?srsltid=AfmBOorFILfn2gmWLyGoHEEmKLux0pDlee_IBav-TOAE9MLC79xltgog

b. DIY - Millward jig (see appendices Millward book for build instructions)

- Drill Press / Dremel method : difficulty is with accurately centring the fluting device as it passes along a narrowing strip and varying the depth of cut , a ball end mill bit is commonly used and consideration must be given to size relative to strip size

c. by Hand … cant really see how this could be done

ii). Scallop & Dam i.e horizontal supports across the strip

a. Milling - Quinchat beveler & digital cane mill , also quite plausible with CNC devices

See youtube video of Quinchat device
https://www.youtube.com/watch?v=82GwbZ_y32Y

b. DIY jigs - Dremel , Router or Drum Sander : a fair number of similar jig examples online

- see Bob Clays rod making video for a router setup that hollows all strips at once … should be possible for a rod maker to make a similar setup with a router or drum sander

- Dremel jigs - one strip at a time
  - see appendix for my Dremel jig

c. by Hand - Files or Sanding blocks with shims

- Poratelli Shark Tooth & Alveolar methods
  http://www.aprods.it/hollow.html

- see Mark Rampants presentation at 2024 Kiwicane
  https://www.kiwicane.com/gatheringskiwicane/kiwicane2024/#linkstopresentations

Note that a Level hollow and Shark Tooth can be seen as the opposite ends of scallop length in Scallop & Dam … the actual hollowing method can be the same

iii). Complex Geometrical internal support longitudinally along the rod

- Magic Star (MHM has an attachment) : note Tom Morgans comments on this technique in the Handmill content information , cutting it is difficult but it has the advantage that the apex angles of each strip need no adjustment , & nestling during binding should follow as per solid hex

- T construction method : requires calculation and cut of the apex meeting point separately…as the apex of an equilateral triangle will only meet at the point , to obtain a surface for glue up in the centre of a Hex needs re-engineering the triangle at the apex by complex milling (see appendices for a plausible DIY method using a planing form)

- the Rose & friends

- note these methods will have a high degree of difficulty for the maker a) in the tip section of a rod
  b) engineering the geometry
  c) planing or machining

- note also it is plausible that the longitudinal internal support such as T construction will have different flex characteristics to Fluting or Scallop&Dam

Some options available to vary Wall thickness along a strip for a maker i.e The Internal Taper

(i) Mills - Morgan Hand Mill

(ii) Make a form - a tapered base template is possible for either the fluting method (with attention to keeping you strip centred) or S&D

- Bob Clays ingenious method of staggered layers of tape on the base of the strip (see videos)

(iii) By Hand i.e adjust your shims as you go along the strip

(iv) Use your planing form - see appendices for method

- allows adjustments of the internal taper at the same intervals as the external taper

Some other notes on hollow building…

1. Nodes - there is little data on spacing , aligning with a dam or hollowing straight through nodes

- Winston Fluted rods are not Nodeless and do not have internal dams or supports , the assumption is they flute through nodes and I can find no reports of breakage (neither are Maca's level extreme hollow rods)

- Powell rods have a 2x2x2 node spacing but there is no data on relationship to dams , the assumption is hollowing just goes through them

2. Consideration should be given to node spacing , or splice spacing if nodeless … if the maker considers these a weakness then there may be some advantage to a Spiral or Garrison stagger for a hollow rod … or aligning with a dam

3. Culm selection may be even more important than for solid building

- Orvis published in 1975 a comparison of Bamboo , Fibreglass & Graphite & mentioned only 5% of their purchased bamboo was of sufficient quality to be used (not a luxury the amateur builder could afford !) and an interesting introduction to the differences between these materials .

- Material variability in bamboo was found to have a significant impact on the action of a fly rod with respect to taper.

The Effect of Material Variability on the Deflflection of Bamboo Fly Rods

Bennett R. Scully University of Maine

4. Extreme hollowing makes it easy to twist the section during binding with a Garrison binder

5. It is easy to break a hollowed strip either when hollowing or handling ! They are very bendy

6. If leaving a safety margin at tip top , ferrule and grip , you will need to mark exact section lengths on the outside surface of your strips before you hollow.

7. Tip sections are more difficult to hollow than Butts !

8. Ferrules – rounding the section to fit a ferrule must take into account wall thickness and safety margin

- splice joins obviously must be solid … if say the join is 3” long with a 1” safety margin at each end then there will be a 5” solid section at that point

- more ferrules/joins = more solid sections & less hollowing

4. Effects of Hollowing ...mostly relating to Hex , but likely the principles can apply to other configurations also .

A comparison of the different methods of build with respect to their effects has to my knowledge not been performed.

The closest would be Sichers experiment , which mostly focused on geometry/configuration ,and we have no data on the internal variables used .

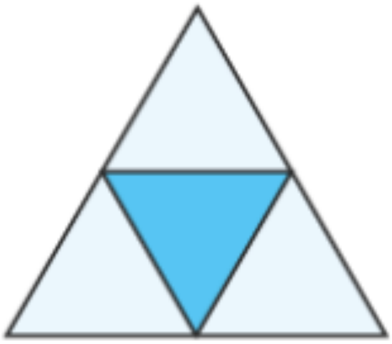
Also Millward , but it is not clear what method he used for his data , the simple assumption would be only Fluting given photos of fluted hollow sections and a plan for a fluting jig in the appendices .

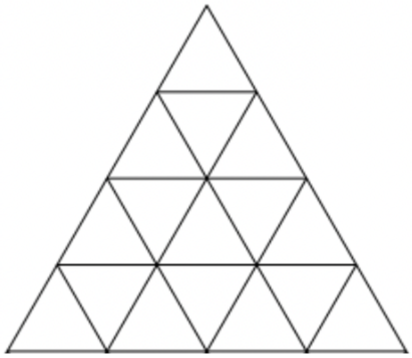
i) . Weight Reduction

Mostly in the Butt section : by my measurement > 80 % total weight savings are achieved here

For a Hexagonal section a 50% strip height would result in a 25% reduction in volume …actual weight reduction will be a little less as pith weighs less and power fibre density reduces as you move away from the surface (i.e the base of our triangle) , also there likely would be some culm to culm variation

Note a 1/3 strip height would have ~44% volume reduction & a 25% strip height 56.25%volume reduction … count the triangles !





A level hollow would have the most weight reduction for a given wall thickness

Weight reduction in all other methods will depend on their internal variables i.e size and no. of dams & scallops , size of post in the magic star , size of lateral walls in fluting

There are claims for Fluting and Magic Star to have greater degrees of weight reduction for equal wall thickness but to compare this to Scallop & Dam requires data on internal variables , i.e Scallop length & Dam size , Flute size or Magic Star Post

Grady , Lamberson and Morgan at Catskills 2015 compared a solid level 320 thou Hex section to the same made using a Morgan Handmill by Fluting and Magic Star with a 50 and 55 thou wall thickness respectively (and a 45 thou wide post for the Star)

Resulting in ~30% weight reduction for Fluting and ~18% for Magic Star for the glued up but unbuilt sections

ii). Flexibility Increase

This is measurable

Note : by the Common Cents System this should reduce the line weight for a given taper

It is possible different hollowing methods may yield different degrees of change to flex for an equal amount of weight reduction… consider the complex internal geometry methods versus a level hollow , also consider the shark tooth method of Poratelli where a picture on his website shows equal flex compared to a solid rod

See Millward section 2.3 for a comparison of diameters (i.e flat to flat) to achieve equal flex for various wall thicknesses … in general this requires a small increase in diameter of around 4-5%… there are many online discussions debating the % increase required which do not take into account the internal variables other than wall thickness

Note that many engineering concepts are not directly comparable , vis the commonly stated “ a hollow tube is stiffer than a solid rod” only applies when the 2 are of the same mass , and there still is a point where the wall becomes so thin it will buckle and the diameter so large it is impractical

Grady , Lamberson and Morgan at Catskills 2015 reported in their section experiment that compared to Solid , the Star section had 7% greater sag under weight , and the Fluted 18% .

iii). Strength Reduction

3 potential strength problems with hollowing

a. Buckling (i.e bend a pipe til it buckles) likely causes a fracture due to excess load during casting

b. Ovalisation of a hollow tube under load (note in a carbon fibre rod graphite fibres run both longitudinally and horizontally to prevent this) i.e likely causes longitudinal split

note also that ovalisation will likely occur before buckling except for build methods with sufficient internal supports

c. Glue line failure due reduced surface area of glued section

Some discussion on strength…

These problems are largely anecdotal , but seem logical … of course most rodmakers / tackle manufacturers are unwilling to say their rods have broken

It would appear obvious that strength is reduced relative to wall thickness , internal support and casting load , but how much and whether it makes a difference in angling scenarios and whether different hollowing methods influence it is less clear .

In general it appears the degree of hollowing should be proportional to the load in the anticipated use of the rod , and that hollowing will be intolerant of any errors in glue up . It is plausible complex internal geometries will respond to ovalisation or buckling stresses differently to S&D and Fluting.

The evidence of broken rods is slim and includes …

- 1930s Casting Competitions had multiple reports of rod breakage (perhaps part of the rationale for Powells Cedar Strip Lamination technique)

- A River Runs Through It - Jason Borger reputedly broke Bamboo rods in the shooting of the shadow casting scene before using a Hexagraph rod (uncertain if they were hollowed)

- Internet forums - Longitudinal splits are mentioned as are horizontal breaks & these seem to be in the Butt section rather than the common breakages of solid rods which occur at the ferrule or tip top , few reports of tip breaks

- Mark Rampant reports to Kiwicane on experimenting in saltwater rods

- Anecdotes from Gatherings , usually 2nd hand

Reports of breakage at the glue line ? I couldn't find any other than Mark Rampants report , but it seems reasonable that this is why historical commercial makers all emphasise their glue strength in the advertising material

Fluting theoretically leaves a larger area for glue up , and for the same depth of hollowing leaves more continuous Power fibres (and so also should have less weight reduction , certainly compared to a level hollow) , especially in the Butt section … but is this stronger ? Consider shear stress which is maximal at the surface flat and absent at the centre of a rod .

How much then do glued internal surfaces contribute to strength ?

Plausibly Winston went down the fluting path because of their Patent (& Powell patenting Scallop&Dam closed that path for them)

Effect of Dam size & distribution , and Scallop length on strength is anecdotal but it seems logical that there is an optimum and a point of diminishing returns… which remains to be discovered…and theoretically dams should inhibit ovalisation…excellent introduction of the principles here on Per Brandins website

Leaving a solid section at ferrule , tip top and grip , i.e common breakage points of solid rods … there is little data from established manufacturers , some limited observations from individual makers online , see Bob Clays rod making videos for some discussion

Hollowing may magnify the weakness of an imperfection in the bamboo (visible , measurable , or because of use) , or highlight the natural density of power fibres of an exceptional culm

Stand on my hollow section … yes really it has been done before & you can have a go on my demo section if you come to Cressy Cane

iv). Longevity

It is plausible that Millwards experiments showing all cane rods will eventually come to a breaking point with continued use applies equally to hollowing , this is not likely to be an issue for a single rod/single angler in a fishing lifetime

Plausibly heat treatments effects on longevity noted by Millward may be exacerbated by hollowing but this is conjecture…heat treatment before hollowing would seem logical

Reports are of classic Powell , Winston & Hardy rods holding up as well as any other classic cane rods but there may be a survivor bias at work here .

No reports of hollow rods being more or less likely to take a sett

v). Rod Action

a. Reduced - Swing Weight

- Moment of Inertia “I”
  $I = m \times d^2$
  where m = mass
  d = distance from axis of rotation
- this is self evident as weight is reduced for the same length of rod

- noting for torque $T = I \times \alpha$
  Where alpha = angular acceleration

b. Improved - Recovery
- Damping
- Natural Frequency
- these are frequently reported observations but I could find no scientific verification

c. uncertain - Elasticity : this should be primarily dependent on the material , but shape (hex , quad , pent) and construction method (especially Magic star & friends) may be an influence , as well as type of glue used & amount of glued surface

- Dynamic Rod Recovery or the 'Spring' effect of the flexible lever notable with bamboo may be affected by hollowing … i.e the only independent action a loaded rod can take is to return to straight , and this is a noted characteristic of solid bamboo rods which has its fans (John Geirach liking a rod with a bit of swing weight) … noting also there will be some 'pendulum' action or 'bounce' after this return to straight occurs that hollowing may improve often referred to as Damping

Performance enhancement by improving Power to Weight ratios would indicate maximising weight reduction is the optimal strategy … up to a point where the structure is weakened beyond the limits of its intended use , but verification of this is to date only by empirical experiment and observation of individual makers (i.e increasingly hollow til rod breaks then back off)

I note the conclusions 3 & 4 of Japanese researchers Nishiyama and Sato published in Nature 2022 (without fully understanding their implications)

nature > scientific reports > articles > article

Article | Open access | Published: 14 February 2022

Structural rationalities of tapered hollow cylindrical beams and their use in Japanese traditional bamboo fishing rods

Ryo Nishiyama & Motohiro Sato

Scientific Reports **12**, Article number: 2448 (2022) | Cite this article

2389 Accesses | **3** Citations | **11** Altmetric | Metrics

Conlcuding

(3) The shape of the slender rod was optimized by changing the taper and dimensionless load under equal volume and height conditions. In addition, considering the hollowing of the rods, the optimal taper was derived from the dimensionless load and hollowing ratio.

(4) It was shown that the bending stress could be minimized equally for various ranges of loading conditions by hollowing out slender tapered rods.

Practical measurement of Rod Recovery (i.e the return to straight or "Spring") and Damping (i.e lessening of bounce) remain to be discovered , current options include

- observation of waves in the rod leg of a cast are probably best … noting proficient casters can modify this with trajectory , managing the deceleration at Stop , drift , and grip strength modulation (i.e squeeze at the Stop)

- Common Cents Rod Frequency of Hanneman , Tackle Frequency & Action Parameter of Le Breton (see de Lespinay)

- video of of the S bend in bamboo rods during casting

Distribution of weight reduction by hollowing technique may have a substantial contribution to action as the Lever effect magnifies weight reduction in the Tip section

Some weight comparisons …

22.5 g = tip section of my version of a solid build 2 piece Garrison 212 taper (a 20% weight reduction hollowing for a built section would be generous & = 18 g for the new section)

9.1g = 30’ average #5 line (10.4 g = #6)

7.4 g = 13/64 CSE super swiss ferrule (1 male)

3.65 g = 13/64 CSE micro ferrule (v similar for Hariki & AVYoung)

0.24 g = 4/64 light wire tip top

0.1 g = 2.5 mm tungsten bead

So my devils advocate question is when casting do you notice going up a line weight ?
What about going to a 2.5mm beaded PheasantTailNymph from a plain PTN ?
And whereabouts on the lever is their weight?

Philip Sicher’s 12 rod geometry experiment with the same starting taper converted using Gabriel Goris (Italy) software to calculate an identical MOI for each rod had a subjective evaluation of casting , but no measurable data on rod action I can find … and unfortunately we do not know the wall thickness chosen , or whether S&D or a level taper was used for the Evo 6 & 8 rods

Measurements of a rods Casting performance available at present are subjective , not least because of inter-caster variation , though there is a significant possibility of video analysis contributing to our understanding

5. Simplified Empirical Schools of External Taper design for hollowed rods

i). Increase External diameter

To achieve a stiffer rod with improved moment of inertia and recovery

i.e Jocelyn d'Lespinay & Italian casting school (stiff short rods , see tapers in 'My Fly Rod')

ii). Reduce External Diameter

To achieve a lighter rod with reduced loading/swing/ tip bounce while maintaining the improved MOI & damping

Note with a lighter line weight this may give the feel of a faster rod action

Also a lighter tip & mid doesn't need a heavy butt to support it .

Excellent comment regarding this technique on CFRF by Tim Abbott here (post 6 on page 2)

http://classicflyrodforum.com/forum/viewtopic.php?t=98394&sid=f8e56462e557b0d4ff91dd6ecc93f933&start=20

Note also the approach of some Japanese makers whose goal is more flex , distributed where they want it in the rod for Japanese style casting

See Cressy Cane ‘23 and links via Nick Taransky’s website for information on the Japanese Long Drift Leader technique , how to cast it and Japanese bamboo rods and their action , and Peter Hayes’s article on Flystream about the same here ,
https://flystream.com/being-better-20/

iii). A combination of the two …

My interpretation of the West Coast School of longer lighter bamboo rods is some West Coast makers relatively increasing the diameter along the tip section to achieve improved responsiveness in a faster lighter tip , while other West Coast makers relatively reduce the Butt section (as a lighter tip & mid doesn’t need a thicker butt) or apply a combination of these

A comment on using Engineered Rod Design methods and programs that were initially intended for solid rods (i.e Garrisons Stress Curves) that may not be directly transferrable to hollow rods , and have assumptions on rod action usually based on a single variable such as Weight reduction & Moment on Inertia that may not give the whole picture of the effects of hollowing … these remain to be verified by a repeatable casting analysis of the finished rod as opposed to a theoretical calculation

See Alberto Poratelli’s presentation at IBRA 2024 written up in IBRA journal for a discussion about the application of Gabriel Gori’s software

Hexrod has an excellent program for hollowing , calculating taper based on either Stiffness , Garrison stress curves or rod tip Deflection , and also an excellent discussion on theoretical considerations for calculating a hollow rod taper using a Scallop and Dam method

See https://www.hexrod.net/Hexrod_doc/hexrod-doc.html#hollowing

“ 4. Hollow Building. Hollowing affects stress in two ways: it reduces weight, thereby reducing the bamboo moments and reducing stress, and it changes the structure of the beam (rod), raising stress in the remaining cane. It is difficult to predict in advance which of these will dominate a particular problem.
There are several methods of hollowing, the most common being scallops and dams and fluting. Hexrod allows for a simple scallop and dam hollowing. You have the choice of either computing stresses for the hollow rod, or computing a new taper to match the original stresses. The paper by Claude Freaner gives some of the math involved. See also Mike McGuire: Dimension compen- sation for hollowing bamboo rods. http://mmcgr.users.sonic.net/HollowComp/HollowCompensation.html “

There are also many discussions on the ClassicFlyRodForum that I interpret as well reasoned debates on the merits of an engineered or an empirical approach to rod design (a selection of these is included in the appendices)

Per Brandin makes a pithy comment in the Catskills Gathering 2015 Hollowing booklet ,

“ Just making a rod hollow does not make a great rod however , it is still the primary external taper that determines the overall action … it is the distribution of weight and stiffness in a rod that …(by) hollow building increases the amount of control we have over rod action and allows us to build longer rods with very positive actions”

6. The Internal Taper

Fluting , Magic Star and Scallop&Dam may not be directly comparable … doing the mathematics of similar cross sectional areas is possible but likely will not account for these different builds…the principles should be similar if we are mainly considering distribution of weight reduction

Published …hmmm , books or periodicals that include sections on hollowing say little on how much and where … mostly the conclusion is you should experiment yourself

See Bob Millward for a discussion of taper design principles

Jocelyn D'Lespinay gives Hex external tapers including for some Daniel Bremond rods and a simple by Hand hollowing Scallop & Dam method that can be used for these tapers

Jack Howells The Lovely Reed has a paragraph on Hollowing but no directions

Per Brandin - A Fly Rod with a Soul is a history of EC Powell rods with no direct "how to do it" section but plenty of information from which one can make some interesting deductions about Hex tapers and S&D method

Most periodicals and forums do not address the internal taper as a design variable with specifics but state observations on method or a rodmakers preference

A very small number of makers websites specify their method & wall thickness… none include the other build variables

Hexrod's excellent program mostly addresses an external taper for given internal parameters…it is however possible to reverse engineer

The devils advocate again asks you to consider the effect changing the external taper of a solid rod by 10 thou has on rod action … what then is the effect of changing the internal taper by 10 thou ?

In general the options to decide on are

i) . Wall thickness , either

a. % of strip height
i.e 50% strip height throughout

b. Level
i.e 50 thou fixed all along the strip til rod is less than 100 thou , then solid for remainder of tip

c. Tapered
- design a wall thickness taper
- tip/mid/butt specific level approach for each section
- hollow butt , solid tip ala Winston

ii). Fluting vs Scallop&Dam vs Magic Star & friends vs Level

a. if Fluting : Slot v Ball for fluting & then size

b. Scallop length & Dam Size … and again fixed versus varied/tapered along the rod

c. Size of centre upright for Magic Star

- complexity of build significantly limits no. of builders attempting this outside of MHM users

- no data available of build specifics other than geometry

d. The level approach

- ie continuous Scallop with no Dams

- Wayne Maca approach

“What’s more exciting is that Wayne’s rods are hollow built. Not fluted, not scalloped, but 100% hollow. His process removes all of the pith from the strips, then tapered, and finally coated with a special resin to increase the strength. His wall thickness is .030 to .070 through both butt and tip sections. Weight problem is solved, and the strength is inherent.”

Powerfibers Oct 2004 article by Joe Byrd

- a few discussions on CFRF of a 50% of strip height being an viable option in one makers experience for a level taper

iii) . Safety Margins at Tip Top , Ferrules , Grip

Anything from 1” to 3” is mentioned , as is reducing scallop length or transitioning to Shark Tooth when approaching these potential weak points

So what can be Deduced from the Internet and other Sources about the Internal Taper ?

1. Fluting - Winston hollowed the Butt section only (this is where almost all the weight savings come from , and would leave a relatively stiffer solid tip section but without the leveraged effect of weight savings there) , little info on their chosen wall thickness , some reports of a continuous level flute with a plug at the end being their chosen method

2. Scallop&Dam - 70 thou level taper from Powell (this was the depth of bamboo with the Port Orford Cedar laminated on top) , maybe increased for Spey type rods , and down to 50 thou for Trout Rods … discussed in “A Fly Rod with A Soul” , no information about an internal taper

- discussions on ClassicFlyRod forum / in Powerfibres / The Planing Form / bamboorodmaking.com / IBRA periodical all mostly focus on thickness at butt ,and only occasionally at tip

- Butt 50-70 thou for trout rods , 70-90 thou for Spey , Tips down to 30 thou (with extreme hollow to 15 thou) seems fairly representative

- little discussion of scallop length & dam size other than considering shorter scallops for safety as you approach Tip Top , Ferrule & Grip … and variable opinions on the merit of this

7.Rod Lengths and Line weights for Hollowing

Some common discussion items reoccur …

(i) Benefits of hollowing rods less than 7‘6 are limited

(ii) Parabolic tapers do not benefit from hollowing

(iii) Both that Trout Rods greater than than 8’6 haven’t been demonstrated to be significantly improved by hollowing i.e still have a tip heavy feel …and that it isn’t worth hollowing until over 8’6 rod length …hmmm

(iv) Spey and Trout Spey Rods in hollowed bamboo have some unique characteristics for these methods of casting/ fishing i.e for anchored casts

There is very little information available to evaluate these discussion points other than individual makers opinion and anglers reported experience…which we shouldn’t discount as accumulated experience is often the best evidence we have … but there is no published info comparable to Millwards review of flex , or de Lespinays tapers

A look at hollow rods currently offered in 2024 by professional makers gives some interesting data with relatively few trout rods over 8’6 , the shorter rods are numerous in all line weights down to 6’ ,there is a fair representation of Spey rods , but only two saltwater specific rods that I could find , and a fair number of makers claim a parabolic action .

Maker	Trout Rod lengths	Trout Line weights	No. rod models on website	Configuration	2/3/4 piece rods	2 Handed, Salmon & Switch	Saltwater & Bass
Brandin (USA)	7’6 - 8’6	3-7	16	Quad 11 & Hex 5	8/8/0	5 rods 8’9 - 9’6 # 7-9 12’6 #7 2H	
Wojnicki (USA)	6’2 - 8’6	2-6	23	Penta 10 & Hex 13	21/3/0	8’8-10 #7-8 3 rods 9’2-5 150-200gr glass ferrule	
Reams(USA)	7’5-9’	3-7	16	Hex only	13/3/0		
Winston (USA)	6’6-9’	3-6	28	Hex only	14/14/0		
W Maca (USA)	**7’6-8’6**	4—7	4	Hex only	unclear , likley 2 piece only		
Hidy (USA)	**6’-8’6**	2-8	41	Hex only	23/18/0		
Hanson (USA)	**8’-8’3 8’6**	2-4 7		Hex	2 & 3 piece		Saltwater 8’6 #7 reportedly
Raine (USA)	**7’-8’3**	4-5	5	Hex	2 piece		
Vance (USA)	**8’4-8’6**	4-6	5	Hex	4/1/0		
Thramer (USA)	**7’-9’**	4-8	14	Hex	6/8/0/		
Clay (Canada)	**7’6-9’**	4-8	9	Hex & Penta	6/3/0	10’6-14’	
Reid (Canada)	**7’0-8’8**	3-6	9	Hex	2 piece	8’6 #7 & 8’9#8 Steelhead 10’6-13’ TwoHand	8883 salt special
Jorgensen (Denmark)	**7’-‘8'**	3-5	8	Hex	2 piece		
Piazetchnikow (France)	**5’7-8’6 6’6-9’**	3-4 5	9 7	Hex	2 piece 4/3/0		

Maker	Trout Rod lengths	Trout Line weights	No. rod models on website	Configuration	2/3/4 piece rods	2 Handed, Salmon & Switch	Saltwater & Bass
Pouey-Sanchou (France)	**7'2-7'6**	5	3	Hex	2/1/0	10'6 Tenkara 12'6 Salmon	
Rigal (France)	**5'-7'2 * French models** **7'6-9' * American**	3-5 4-5	5 4	Hex Hex	2 piece 2 piece	11' 3 piece	* also offers planing forms & 60 degree milling cutters
Rhyl (Denmark)	**7'** **7"6**	3 4	2	Hex	2 piece 4 piece		
Zumbrunn (Switzerland)	**6'6-7'6**	3-5	3	TriHex	2 piece		
de Lespinay (France)	**7-7'6**	4-5	2	Hex	2 piece		
Kakuhiro (Japan)	**6'9-8'6**	3-6	9	Hex Hachiku	4 piece		
Shindo (Japan)	**7'6-8'6**	4-6	3	Hex	3 piece		
Harada (Japan)	**6'6-7'6**	0-4	12	Hex Madake	0/8/4		
Fagus (Japan)	**6'7-7'5**	3-4	5	Hex	3 piece		
Tokachi (Japan)	**7'3-9'**	3-6	16	Hex	3 piece		
Bum Rod (Japan)	**7'6 -8'** **8'-8'3**	3 4-5	3 3	A6 Hachiku A8 Tonkin	3 piece		
Akimaru (Japan)	**6'4 -8'3**	3-5	15	Hex	11/4/0		
Martorelli (Argnetina)				Hex Fluted Argentinian Native Bamboo			

This is not intended to be a complete list of hollow makers and for brevity I have included those that offer Hollow rods of their own tapers , and that I am aware of , and that have a website navigable to a monoglot (or to google translate), and I have focused on Trout rods … many excellent makers are undoubtedly not here , mostly due to my limited research or language skills .

So for example I have not included Sweetgrass , Tom Morgan Rodsmiths or Chris Carlin as it is unclear to me from their websites which models are specifically designed as hollow among their offerings , and Takemoto Rods T construction as I could not confidently navigate the website in Japanese , and some other makers do not list a rod menu or only offer hollowing for custom requests.I would like to have included Boshoff of South Africa whose facebook has pics of hollowed strips but there was insufficient data to get a maker in every continent .

Some websites from which I have gathered information are dated … I still think this is a fairly representative range of what hollowing can offer which was the intention .

Interestingly the average longest rod in Nth America is about 8’6 , and in Europe about 7’6 .

Inexperience tempts me to think that the sweet spot for Hollowed Trout rods is from 7’6” to 8’6” rod length for a line weight of # 4-6 , with both longer and shorter rods possible for skilled makers (I do not have enough data or experience to draw a conclusion on rods for Spey , Japanese or Italian style casting)

8. A proposed system of Internal Tapers for amateur rodmakers using a Scallop & Dam method
(being the easiest method for an amateur rod maker)

i) **Dams** 0.125” (1/8”) for 5 weight and under , 0.1875” (3/16”) 6 and 7 weight , 0.25” (1/4”) 8 weight and above

ii) Scallops 8x rods flat to flat diameter rounded to nearest 0.25”

i.e At 300 thou scallop is 2.5”

250	2.0”
200	1.5”
150	1.25”
125	1.0”
100	0.75”
62.5 (4/64)	0.5”

for the really keen you could calculate this at each 5” station or scallop

note - this is based on observation of the average internode to diameter ratio on my stash of Tonkin cane and my assumption that a factor of 8 makes for easy calculation, & consideration that bamboo has naturally evolved with a hollow core that has dams

- a smaller factor , say 6 , would possibly have more strength through more dams but the tradeoff is less weight reduction

- for rods 8 weight and above which have a greater casting load (and target species size) consider decreasing the ratio as you approach the butt i.e 8x in tip , 6x mid , 4x butt noting that in a culm the internodes decrease closer to the butt

iii) Wall thickness

a. Butt wall thickness is according to intended line weight with 10 thou per line weight

i.e 30 thou for 3 weight

50 thou for 5 weight

70 thou for 7 weight

90 thou for 9 weight etc

note - below 3 weight things get a little tricky !

b. Tip wall thickness is either

E : for the extremists
- 50% of Butt Wall thickness at tip
- tapering from butt to tip evenly in 10 thou increments

P : for the practical
- 30 thou if 6 weight or less
- 50 thou 7 weight or greater
- tapering the wall thickness in 10 thou increments evenly

L : level for those wanting to make their life easy

iv). Safety Margin at Tip Top , Ferrules & Grip of 1”

- noting this is the amount also recommended by Millward

- consider transitioning to solid by a Shark Tooth method over the last scallop

Some thoughts on External Taper correlation

Adjust external taper according to where you want the rod to flex (tip , mid , butt) and how much loading you like , and desired casting characteristics for your angling

i.e more hollowing & less external diameter = more flex
to achieve less flex for a given amount of hollowing the external diameter must be increased

Consider Powells classic approach to tapers with the descriptions of being either a Tip or Butt action and the rod either Flexing or Resisting at these points .

Consider weight reduction at the Tip Top , Ferrule and Stripping Guide as these will exert the most influence on rod action as per leverage

An Opinion - hollowing existing classic tapers to achieve the same action with a lighter rod may or may not be possible …or desirable … the casting characteristics of those classic rods are dependent on their construction … makers with respect for and devotion to the classic tapers will have noted that hollowing shall change swing weight , moments of inertia , responsiveness , loading etc and result in a new rod .

Appendices

1. **References**

- R.E. Millward "Bamboo Fact , Fiction & Flyrods II" 2010 : the only detailed treatment of hollowing available for the amateur rod maker (Self published)

- Jocelyn de Lespinay "My Fly Rod" 2010 : the only reference that provides both an external taper and internal hollowing method (Self published)

- Todd Larson " Radical Rodmaking" (Whitefish Press)

- Yuki Bando " Mostly Bamboo" (Flybito Press)

- Per Brandin " A Fly Rod with a Soul. The Bamboo Fishing Rods and Life of E.C. Powell, Angler " (Little West Kill Press)

- Philip Sichers rod experiment https://bambusruten.dev-zulauf.ch/rutenbau/ruten-querschnitte/

- IBRA issue 28 January 2025 detailing the hollowing gathering of November ’24 by Poratelli et al

- Catskills Gathering 2015 Hollowing Booklet

Magazines / Periodicals

- The Planing Form
- Powerfibres
- IBRA Journal

Internet Sources

- ClassicFlyRodForum

- bamboorodmaking.com

- splitcaneinfo.com **see for links to multiple makers websites**

- Bob Clays rod making course videos via Anchored Outdoors (an excellent series by a renowned hollow maker with much information)

- Hexrod

2 . Selected CFRF posts , being in my interpretation well reasoned discussions on the empirical and engineered approaches to hollow rod design respectively

(i) Abbott comment via CFRF topic – Modern Hollowbuilt rods (originally from Catskills booklet)

HOLLOW BUILDING INSIGHTS AND OBSERVATIONS

While many makers are hollow building rods, those that understand how to combine the taper with hollowing are rare. Anyone can remove material and make a rod lighter, but actually making a better rod does not seem to be a priority for most. This is not really surprising as I estimate less than 1% of makers have any grasp of taper design. The tendency of many to simply go online to find information rather than learn for themselves, adds to the knowledge gap. Add this to the sheer amount of misinformation available and the average maker is doomed to mediocrity.

So what is hollowing all about? POWER TO WEIGHT RATIO! I spent many years designing successful racing cars and understand the concept well. Simply put, if you have a fixed amount of power available, any weight you can shed will add to the performance. You will accelerate quicker, stop quicker, and be more responsive all over. How does this apply to a fishing rod? A taper does not make power, but it stores energy. The amount it can store is finite. In casting, this energy must overcome the mass of the rod as well as that of the line and any other loading to accelerate. It must also recover the mass as well. If mass is removed from the rod, more of this energy is available to propel the line. Now this is where it gets tricky. The mass of the rod also helps with loading the rod. If you can't load the rod, you won't store as much energy. Some have noted that when they hollowed a rod, it took a higher line weight. This, they wrongly attributed to the rod becoming stiffer. This is not the case however. It is due to less self loading. Another observation is that the rod feels faster or crisper. An underlined rod will feel faster but an improved power to weight ratio makes for a faster rod as well.

Weight has a great effect on how a rod casts. It is very easy to add a little weight to a rod and see for yourself how it responds. I have several 1 piece rods, both solid and hollow. By using lead tape, I can simulate the weight of ferrules and their placement and get an immediate feedback. Also, weight can be added at any point, cast and removed to get a sense of how weight in various places on the rod affects the cast. Making a 1 piece rod is similar to hollowing in that by removing the weight of a ferrule, it does not load as effectively as it did in a multi piece configuration. It is very informative to cast rods with different lines and really concentrate on how it loads. If for instance, you have a favorite 5 weight taper that you hollowed and it loads better with a 6 weight, you now have a choice. The rod just told you that to keep it as a 5 weight you must modify the taper or to make a better 6 weight the same is true. To keep it a 5 weight, the tip is still a 5 weight but at some point the rod stops loading properly. Your goal should be to determine the area where you need to start REDUCING the taper. This is not straight forward as there is much variation in taper styles. Depending on the type of taper, the amount of mass available for removable and its location will vary. Also the length of the rod has a definite effect due to the leverage. There is also no 1 to 1 trade between weight removed and line weight as the line is loading from the tip top and the mass removed is lower and throughout the rod. Try to develop a feel when casting to sense where you need to modify.

There are those who feel that this can be dealt with by simple engineering. Let's look at this. The basic concept is that you calculate the stiffness of the diameter and then subtract the stiffness of the diameter of the amount you remove. You then recalculate the diameter to reclaim the stiffness that you lost from hollowing thus creating a new taper. The claim is that it will then cast exactly the same as the hollow version but be lighter. This is a valid engineering method for structural design but improperly applied for our application.

It is based on the material being homogenous and consistent. Bamboo is neither.

It assumes a solid model to start with and as bamboo's strength decreases as we move away from the outside towards the pith, the engineering model cannot compensate for this loss of strength.

It does not allow for any internal structure such as dams, flutes, ribs, etc. where it effectively becomes a truss, not a hollow tube.

It is based on static deflection, not dynamic deflection to which response and recovery are part of the equation, not just dead load.

It does not compensate for the weight reduction and reduced self loading on the polar moment. Also it ALWAYS calls for an increase in diameter when the rod might be asking for a decrease in diameter. LISTEN TO THE ROD!

Garrison used his engineering to develop a baseline taper but then used empirical design to make it a better fishing rod. The same logic applies to hollowing. Always trust the ROD over the text books!

There is one very useful thing to keep in mind based on this engineering principle. The same amount of material can be made stiffer by increasing the diameter and reducing the wall thickness. You can therefor increase the stiffness of a section without increasing the weight.

If you wish to develop better hollow building techniques, it is best to start with something familiar. Ideally, chose a taper you are familiar with. You also need to choose which method of hollow building you wish to work with. It is important to have a process that is accurate and repeatable. If you build 2 rods, as close to identical as possible with the exception that one is hollowed, you now have something to compare. Cast the rods side by side and concentrate on how they load and any differences you might detect. Try different lines to see if another choice feels better. It is best to do this on several occasions as preconceived ideas can cloud your objectiveness on first impressions. Depending on the taper, what you feel may be subtle or dramatic. What you are looking for are any differences and where they occur in the cast. Sometimes a change can be seen more than felt, such as a different loop profile. This will give you an idea about the effect hollowing had on this particular taper. Make note of how much weight you removed and from where in the rod it was removed. Weigh the rod before glue up and after cleaning the blank to see how much glue is retained in the hollows. This information will be

useful as you continue to develop and refine tapers. Once you have an idea of how the hollowing influences the cast, you can form a plan on how to proceed next with development. Depending on the taper you start with, you might decide that you do not find any real benefit for the extra work involved or you may find a noticeable improvement that stimulates you to explore more options. Shorter, lighter rods do not show as dramatic a change as longer, heavier rods but it can still be noticed. In a longer rod, hollowing is more noticeable because there is more potential weight to be removed and more leverage acting on the rod.
There is no substitute for actually building a rod and casting it. With different tapers and different casting styles, there is no “one size fits all” answer to hollowing. Those who keep exploring are rewarded for their efforts.
This is by no means a comprehensive study of hollow building, but just a few thoughts and observations put down as I prepare for the 2015 Catskill Gathering.

Tim Abbott

(ii) from “Does hollowing reduce rod life“ topic

http://classicflyrodforum.com/forum/viewtopic.php?t=100360&start=40

My thoughts on your questions.

Is there any guiding info on hollow building? Seems like solid rods are reasonably well understood but hollowing introduces a whole whack of variables.

Yes, there is. It is called the Euler Bernoulli beam. It is not perfect but is plenty close enough.

Things like:
1) style of dams

Don't be abrupt going from hollow to dam. I use a 1/4" diameter burr for cutting scallops. Keep the dams as short as possible and they dissappear from the stiffness equation for the most part.

2) distance between dams

7 x diameter of the rod section at the tip end of the scallop is the maximum I will use. Number was determined by experiments.

3) glue types

Use a glue with little creep. I use Nyatex. If I had to use anything else it would be resorcinol or some urea formaldehyde glue and in that order.

4) sidewall thickness

My spey rods are 0.015" at the tip and 0.080" - 0100" at the butt. The thinnest wall you can use on any rod is determined by the size of the power fiber bundles and the density of power fibers of the bamboo. Right now that dimension is up for grabs.

5) dam locations in relationship to guides, ferrules etc.

Don't worry about guide placement in relation to dams. That is overthinking the problem. I stay 1/2" away from the mouth of the ferrules. The area around the mouth of the ferrules deserves special attention.

I'm sure there are more!!??

Not much. You got the high points.

Did an experiment some years ago comparing solid to hollow rods. Built a router based hollowing/dam machine and built two rods utilizing the same taper and cane intermixed, to in as much as possible, make the rods the same. In my hands, the hollow Rod cast about 15' shorter than the solid one. Turfed the whole hollowing thing.

Your results are exactly what I would expect. The stiffness profile of your hollow rod is different than that of the solid rod. At any given point along your rod the hollow rod is not as stiff as the solid rod.

The book "Roark's Formulas for Stress and Strain" is usefull in discovering some of the ins and outs of hollow building.

Hope this helps.
Jerry

57
Post
by **fishbum** » 10/19/16 07:30

Don Andersen wrote:
Jerry,

In the hollow vs solid situation, how much do you add to the taper to go from solid to hollow.
I suspect that the increase cannot be linear but must be a percentage.
I'm thinking 4%.
And is the percentage variable based on glues, dam locations and the like?

Regards,

Don

Don,

The amount you add is dependant upon the wall thickness and the outside diameter. In my own work I first design solid and then change that to hollow. I use the second moment of area (I) and adjust the hollow dimensions so that the second moment of area of the hollow rod is equal to the second moment of area of the original solid rod. Not perfect but it works well enough. In rods smaller that are 6 weight or less, you can pretty much ignore the change in weight of the rod section. Your rod will be just slightly stiffer than necessary to do the same job as the solid rod.
On larger rods you do have to consider the difference in weight and recalculate the moments to get the correct cross section.

It is not a simple "just add a little" type of problem.

Jerry

- #72
Post
by **Mike McGuire** » 11/19/16 15:38

carl otto wrote:
coachmaster:

It would be very interesting, to get the mathematical engineering person, with the practicing rod builder and then an understanding academic who could translate and tie together the technical to write a coherent digestible treatise on contemporary hollow rod building for the masses(at all levels) to peruse.

Carl @ Wanigas Rod Company

I am not going to flaunt my academic credentials, but I will say that I have a background in experimental physics and I am a rodmaker. I have taken a look at this problem of how to compensate a taper for hollowing and have come up with what I hope is a useful contribution. The simplest form of compensation is to keep the cross section moment of inertia constant. This comes down to an equation

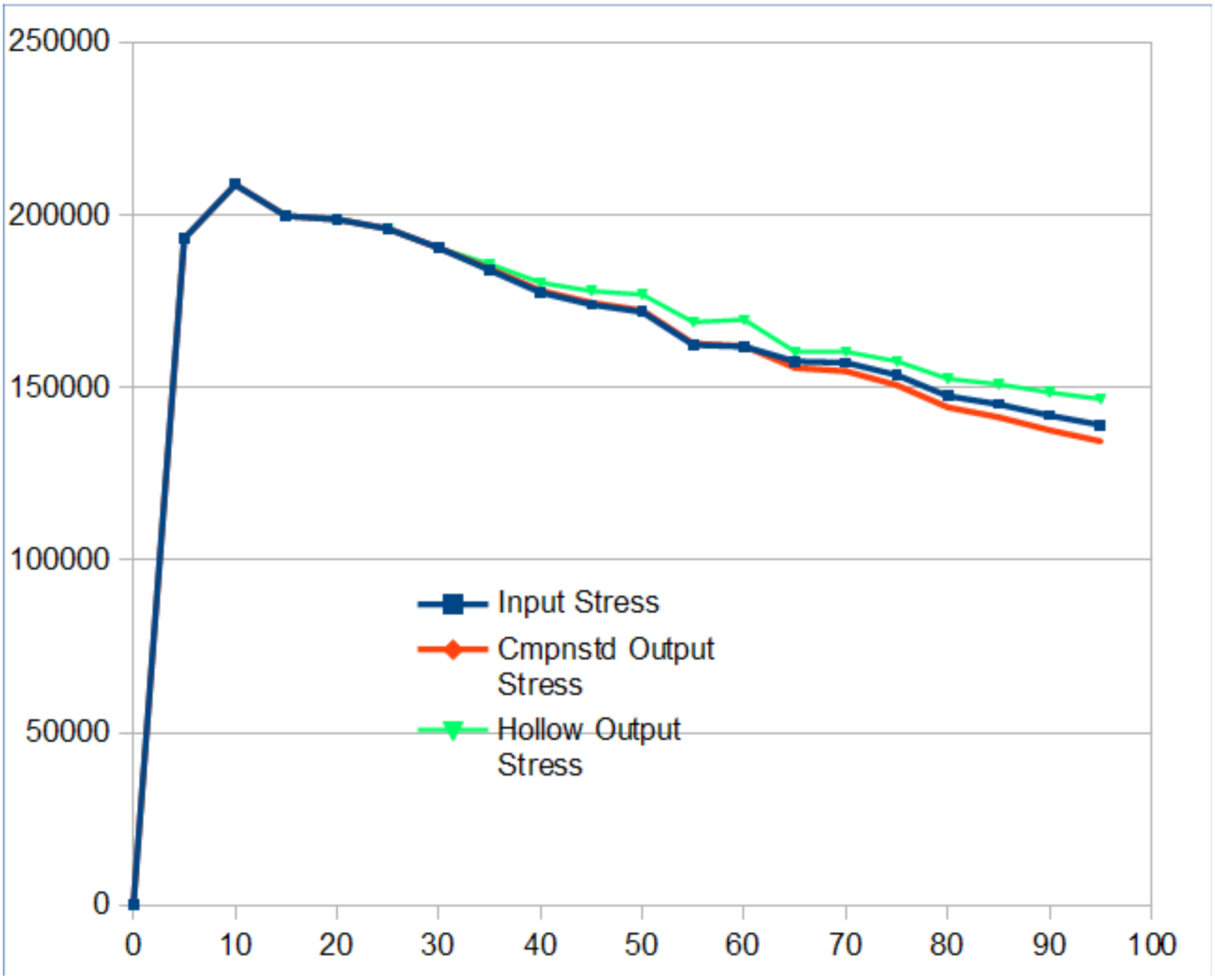
$$d4 = (D - t)4$$

where d is the flat to flat dimension of the solid rod, D the dimension of the hollowed rod, and t the wall thickness. We have to solve this for D. If we expand and rearrange this we get

$$D3 - 3tD2 + 4t2D - 2t3 - d4/8t = 0$$

This is a cubic equation. As with a quadratic equation it can be solved with formulas, but they are pretty complicated with lots of opportunity to make arithmetic errors in the process. To calculate for a whole taper, there would be a cubic equation to solve for every station. To make this easy, I put together a spread sheet to do these calculations. With this in hand it occurred to me that it would be interesting to add a calculation of the stress curve of the hollowed rod. This required modification for hollowed rods of some of the formulas of chapter 14 of Garrison. It wasn't much of a leap to go from this to using the stress curve to calculate a taper compensation for the change in moment of inertia and accounting for the change in weight of the rod. This is like how one calculates a new taper for a different line weight from the stress curve of a given taper and line weight, as is implemented in RodDNA and Hexrod. One difficulty that came up was in the step of going from the moment and stress at a point on the rod to the dimension brought up another cubic equation. This has to be solved for every station of the taper and multiple times as it iterates to the final taper. I though this might be a computational overload, but it doesn't take any noticeable amount of time at all.

Here is result for a Garrison 212 with fairly conservative hollowing, 0.070" wall in the butt third, 0.060" wall in the center third and no hollowing in the tip third.



The green curve is for hollowing with no compensation, the red for simple moment of inertia compensation. The blue curve also applies to the stress curve taper.

The columns are input taper, constant moment taper, and stress curve taper.
0.0720 0.0720 0.0720
0.0840 0.0840 0.0840
0.1040 0.1040 0.1040
0.1220 0.1220 0.1220
0.1360 0.1360 0.1360
0.1490 0.1490 0.1490
0.1620 0.1622 0.1622
0.1750 0.1754 0.1755
0.1880 0.1888 0.1890
0.2000 0.2014 0.2015
0.2120 0.2140 0.2141

0.2280 0.2312 0.2312
0.2400 0.2442 0.2440
0.2540 0.2568 0.2555
0.2660 0.2697 0.2679
0.2800 0.2849 0.2826
0.2960 0.3025 0.2997
0.3100 0.3181 0.3147
0.3250 0.3351 0.3309
0.3400 0.3522 0.3472

There is a considerably more detailed discussion of all this at this page on my website. The spreadsheet is available for download from that page. Instructions for using it are on that page. For those who want the full Missouri treatment, I have laid out the changes to the Garrison formulas at the end of the page.

Happy to answer any questions.

Mike

75
Post
by **Mike McGuire** » 11/20/16 16:11

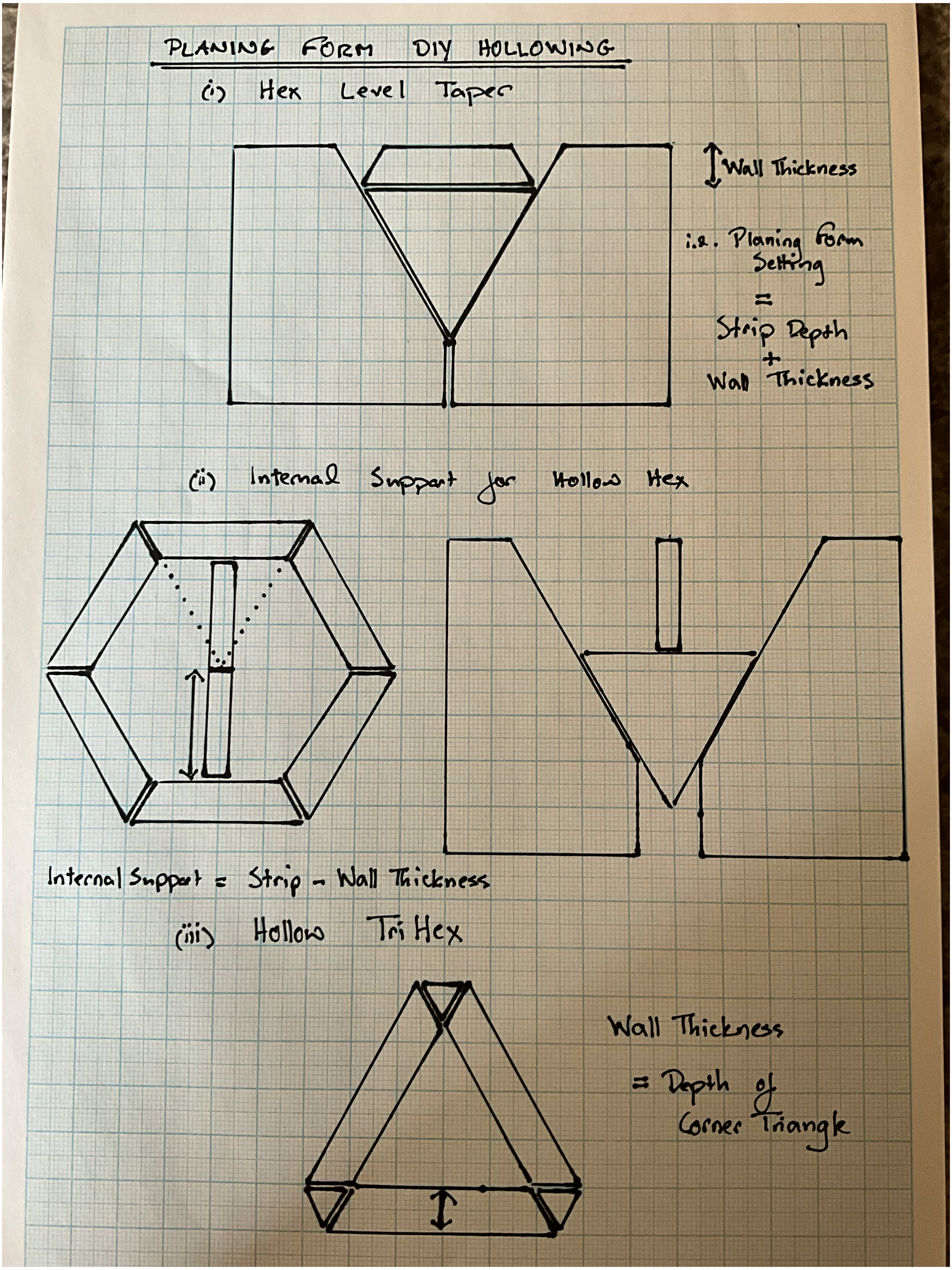
Frank

We have to start somewhere, and the consideration of the effect of hollowing on a uniform material is the obvious place. Understanding this in itself seems to be a difficulty for a number of people posting in this thread. I don't have Milward's book--does he give any sort of functional description of the variation of MOE with depth? If that were so it should be possible to incorporate it in calculations. It would appear that your Hexrod program suffers from the same defect even though it only applies to solid rods. The stress values would be underestimated as the depth of the bamboo increases along the rod, or do you do something to account for that? Never-the-less I have found that Garrison's stress curve methods, as implemented in Hexrod and RodDNA and spreadsheets I have set up, works pretty well for things like deriving a taper for a different line weight from a known taper and line weight. In the absence of something demonstrably better, I am going to stay with this approach. As for weight reduction, if we consider the graph in Diagram No. 18 on page 248 of Garrison, the density varies less than 10% over the length of a solid rod, so it would appear that the weight reduction would be similar to a uniform material.

One way to think about the effect of hollowing is to consider the simple physics of a mass-spring oscillator--hang a weight from a spring, displace it downward from its equilibrium position and it bobs up and down. The frequency varies as the square root of the spring constant (stiffness) divided by the mass (weight). If we increase the spring constant and/or diminish the mass, the frequency goes up, vice-versa it goes down. If we hollow a rod we diminish the mass but we also diminish the spring constant if we don't compensate, so whether the frequency--the rate at which it unloads from a bent condition--goes up or down depends on the details.

Mike

3. Some DIY hollowing possible using a planing form



4. The Bamboo Renaissance

https://www.beaverheadrods.com/images/beavrds_pix/bamboorenaissance.pdf

5. Mike Montagne Speaks Out

An Interview with Mike Montagne By Reed F. Curry

Mike Montagne is an innovator, a thinker, and a rodbuilder (retired) of the first water. I was fortunate to be in touch with him recently and he graciously shared some of his history and theories. He even shared some of his victories, like the near-world-record steelhead below, caught on the Dean.

For those unfamiliar with Mike's rods I quote from Ernest Schwiebert's "Trout":

"But Montagne is a craftsman of startling originality, and not all of his creativity is obvious. Edwards built symmetrical four-strip rods. Montagne builds his sticks at irregular angles to create their widest flats, and the primary power fibers, perpendicular to the planes of casting.

His four-strip design offers twice the density of cane power fibers found in six-strip construction of the same section thickness.

Such four-strip sections offer more than mere power fibers. Montagne rods resist bending across the corners, concentrating deflection in

the casting plane. Such performance tends to correct casting faults that twist other rods. Better distance and accuracy are also improved. Wave- linear behavior is crisp and clean. The ratio of power fibers to inert cane along the neutral bending axis is multiplied, even slightly higher than power fibers in the earlier Edwards Quadrates."

The Interview

Reed: Please tell me more about your taper design software. What approach does it use --- the stress curves of Hexrod, or something entirely different. What inputs does it require and what output does it deliver?

Mike: Those stress curve calculations don't fly with me. I looked over Garrison's work. The technique is crude -- and I never found an explanation in any engineering resources (not that I'm astute there) which qualified moment of inertia theory, his stress calculations as necessarily applied to a member suffering such dramatic bending, or determined just where the neutral axis falls under any given conditions. Thus you have some pretty poor methods there -- because they don't even take into account THE bending -- and the leverage thus imposing the stresses upon the member.

What I found is that the "stress curves" -- or method of calculation used by Garrison -- originate as a crude method intended for instance to analyze the stresses in a bridge. I never found a qualification of the theory ("moment of inertia"), and it appears it makes no effort whatsoever to determine placement of the neutral axis -- which, particularly with disparate high modulus materials such as carbon fiber, is critical to the real stiffness of a section. First and foremost, the stiffness of a section is regulated by the leverage the opposing tension and compression sides have on each other. THEN there is the what I call "effective lever length" -- which is not the actual length of the rod, but the length of the lever through which the resistance is accelerated by each station of the rod. In each station of the rod, ELL is a perpendicular of the LOD, passing through the station. THIS is the leverage acting on that station of the rod -- and Garrison's "stress calculations" don't even venture to determine it.

Maybe I'm all wet there, but I developed my own methods -- which are far more complex, and account for the geometry of the leverage, positioning of the neutral axis, etc.

While useful of course to deliver generic tapers based on accepted designs of assumed merit, extrapolation or interpolation is a far different power than "designing" a rod by computer -- which of course may entail anything from true development comprehensive of physics, to relatively simple empirical extrapolation/ interpolation of/from, and restricted to, the scope of known, accepted models. To go farther than that, or to determine the limits of how far we can go, requires truly comprehensive methods.

"Hexrod" appears to have simply computerized Garrison's ostensible stress calculations, which to my understanding do not even take into consideration effective leverage upon the stations of bending. In other words, what he is trying to calculate isn't what's happening. My approach is from the opposite end of the spectrum. It may be the only such try.

One thing I should mention critical to the further use of data is, unless "tapers" are determined by the original builder's specs for a rod design, data would be inherently very misleading. A few thousandths of an inch are critical to behavior -- and may or may not

suggest flaws in design versus imperfections in manufacture. The database should indicate whether tapers are design specifications or empirical measurement. If the data is from measurement, it should detail every measurement -- expected finish, average or mean of how many rods, etc. I can tell you though they were very accurately made, it would be very difficult to interpret my tapers from measurement.

There was considerable further work I wanted to do and it's very unfortunate I wasn't able to. I would have completed my work if I could have taken my later taper designs into refined rod lengths featuring my later reelseat- grip combination, which comfortably placed the heel of the hand at the very butt of the reelseat, with your little finger against the reel. While my screw uplocking seat weighed a mere 17.5 grams, the later wood seat featured an absolutely rigid connection with the reel, and, owing to ambitious hollowing and sculpting, weighed a mere 8 grams. This provided an effective rod length some 3 inches longer from a given rod. But I also had refined my ideas of how long to build each rod to perform a given workload.

My most "mature" designs were rectangular sections featuring rather dramatic differences in the tapers -- particularly in the taper progress of the upper tip sections, which are the most critical rod segments of faster, compound tapers in any section design.

If data is from measurement, average or mean over numerous rods, it should also indicate it is derived from however many rods, the vintage of each specimen, who measured it, how, and with what, because those who are to interpret the data well must take this into account. Temperature and accuracy of tools of course is also vital to the validity of data. Knowing the builder's methods is also critical for interpreting empirical measurement. Did their equipment and methods render an assembly of straight taper segments, or were transformations progressive? All these respects weigh in what a taper specification or taper data means.

I can tell you I only measured a few rods, if any at all. I don't actually remember measuring any but a few graphite rods, but it's possible I measured a cane rod or two -- at least perhaps a tip or ferrule step.

No, my work was very different. Ultimately the application I developed designs a rod from data about the material: tensile and compressive strength; elongation/compression per stress; and mass. In abiding by maximum unit stress, and in making most efficient use of the material, it always delivers rectangular section designs -- of course, wider across the plane of bending than deep, in the plane of bending. Rectangular section design of course is very different from hexagonal or typical regular

polygonal sections -- and, though a rod may look similar to the naked, simple eye, tapers and taper possibilities are very different.

Nonetheless, my application starts elsewhere. First the question is, "How is a rod to bend/ behave during a casting cycle, to deliver work/

performance most conducive to casting requisites?" This is the central question of all real design attempts. We can develop by understanding, or we can grope at delivering what we think we are improving, slowly, by empirical processes -- building rod after rod, hoping changes contribute to better performance, but not having a formula for optimum performance, and never knowing even if we have really "got there" yet -- or how much further to go to realize virtual optimums.

Oddly perhaps, my rod-building was initiated by an evening's evaluation. If you've seen my original catalog, that evening was born what Andre Puyans used to call Montagne's theory of linear acceleration. All the rationale presented there transpired from something like a half-hour's thought and a single drawing.

What the theory of linear acceleration was, is a geometry (many others -- Mel Krieger, etc... -- have borrowed from it since) for proper operation of a fly rod. The thoughts were inspired by an evening's casting from a platform I regularly practiced at -- but immediately they posed a refutation of Garrison's postulate that a fly rod delivered its energy during the recoil phase of casting. The theory of linear acceleration indicated acceleration occurs instead, during the increasing bending phase of what I call the casting cycle.

No one can truly design a rod from physics and material data, unless they know how a rod best behave, and unless they develop the technology to deliver designs which will deliver that behavior. The first issue thus was to determine how a fly rod best operate during the casting cycle. Much thought has been given this issue over the history of fly fishing, and it is perhaps the most important issue of fly casting. The intrinsics of a proper

analysis are critical not only to fly rod design, but to understanding casting.

My linear acceleration postulate is simple physics and ballistics. Owing to the relatively low sectional density of fly lines (sinking or floating), it is critical how a fly line is accelerated, because it is critical how a fly line behaves as it is presented to the air it passes through. As air resistance affects a fly line dramatically, not only in terms of deceleration, but in terms of aerodynamic behavior as well, there are very definite requisites of acceleration to achieve optimum performance from the fly line.

Owing to the relatively low sectional density of fly lines as compared to the usual projectiles of ballistics, the ideal scenario for distance or distance with minimal energy, is to accelerate a fly line in a linear manner. This presents the least cross-sectional area to air resistance, and renders the greatest possible sectional density -- weight per cross- section presented to air resistance. Greater weight per cross-sectional area retains energy/inertia proportionately better.

In order to achieve linear acceleration, the back-casting stroke has to align the line in what ballistics calls, the "line of departure" (LOD). The LOD is the theoretical (real) line in which the projectile/fly line is ultimately accelerated in.

The theory of linear acceleration thus dictates the casting cycle. If a rod performs the requisites of linear acceleration, then as the fly line is accelerated by the rod, the tip of the rod must take the line of departure (unless the uppermost section is bent into the LOD -- in which case the relevant point is a determinative station of the rod within the LOD).

This means from an initial, relatively inert moment initiating the forward casting cycle, the rod must bend increasingly so as conducting the fly line in the intended LOD, to a moment of greatest bending (MOGB).

The moment of greatest bending then is defined by a point on the LOD where a perpendicular to the LOD, passes through the axis of rotation (AOR). At this point of the casting cycle, the tip is the closest it will be to the butt or AOR. The axis of rotation moves during typical casting practice, but for the most part we can consider it the wrist of the caster -- which moves up and down, forward and backward, in coordination with the bending and recoil of the rodsection.

So you have this semi-horizontal LOD rendering an angle of departure (AOD) necessary to provide a trajectory to reach the target with an intended behavior. We have a beginning of a casting cycle comprised of a relatively inert (hopefully, stabilized) rod, with the fly line aligned in the LOD. We have increasing bending during an increasing bending phase of the casting cycle, to a moment of greatest bending -- conducting the tip/fly line in the LOD. Beyond the MOGB, we have a recoil phase of the casting cycle, and consequent rod behavior during the recoil phase -- generally comprised of recoil beyond the neutral position (owing to inertia during recovery, which carries the rod to and fro with successively less excessive energy, beyond neutral/straight), and a number of vibrations ultimately culminating in "recovery" to or nearly approaching a neutral condition most conducive to initiating the reverse casting cycle when the fly line is poised for reversal of the cycle.

The conclusion of the theory of linear acceleration is that very little if any acceleration is engendered by the recoil phase of such a casting cycle, because recoil can only occur if less acceleration force is applied by the rod; and because, as the tip leaves the LOD under such circumstances, and, as a result of its linkage with the fly line, the tip therefore has less effective forward speed than the fly line -- which already is accelerated in the LOD. In forward and backward casting developing linear acceleration, very little acceleration is engendered by recoil.

While this may define the process and objectives of the physics of the casting cycle, the question still remains, how should the rod bend then during the casting cycle?

When I began, as I understood the issue (largely as Schwiebert presented it), there were three basic schools of thought, which I summarize as the fast, progressive taper theories typified by Powel, Winston, Howells, Dickerson, and others; the school of relatively equal bending throughout the length of the rod as championed by Garrison and his ostensible stress curve calculations; and the parabolic school of design -- where a relatively supple buttsection has little authority over a relatively stiff midsection, usually coupled to a relatively fast tapered upper tip.

An evening I spent with Andre Puyans might typify how the virtues of each were typically weighed -- always by experience affected by little other than how well we can wield each type of instrument without a definition of ideals. Andy one evening had me cast an early E.C. Powell that decided the issue quite clearly on such terms. He sent me outside saying, "CAST IT!" The best six-strip I ever touched. A truly splendid rod. But why?

The parabolic school delivered an ill-behaved instrument -- and we can easily understand why, evaluating the rod over it's incumbent casting cycle (graphed as delivering linear acceleration). Owing to its deficient buttsection, it exercises no authority over the remainder of the rod, and suffers a hugely wide, repetitive, time-consuming (slow) recovery to a neutral condition. "It vibrates." It develops acceleration only by tremendous overloading of the lower butt, and after the MOGB, suffers the widest pattern of recoil, and greatest number of bounces in finishing the casting cycle -- which are communicated to the lower part of the loop.

The parabolic (which is something of a misnomer, as more or less parabolic taper conformations give the performance of the Powell) may cast the farthest per its weight however, because by far the greatest concentration of the weight of a rod is in the buttsection -- and it has none. It may of course NOT cast as far -- it only generates more force per weight. It achieves this perhaps meaningless distinction at the expense of the worst possible behavior, the least control, and great stress on the lower part of the rod -- the latter of which would be a decided disadvantage in building rods for playing steelhead or salmon, but which also produces adverse, uncontrolled, bobbing inertia on light leaders in light fishing.

Some people believe the greatness of a rod is in the taste of the caster. But no caster overrules physics -- all of us have to contend with physics. Our casting is ruled by physics. The physics of the parabolic, on our superficial evaluation (here, so far), are the worst possible. Instant recovery alone is conducive to ideal line behavior, and the necessities of initiating a subsequent casting cycle. The parabolic has the slowest possible recovery -- so slow in fact it is ill prepared for subsequent casting cycle phases. In pictures, you will note the huge forward arcs of rods in the recovery phase of the casting cycle, typically huge loops, and tremendous waves generated in the lower part of the loop. All are the result of inherently terrible recovery characteristics.

Next we have the Garrison school -- rods which ostensibly bend equally throughout their length. The inherent attributes of this class of taper design fall between the parabolic and the faster tapers proven by Powell, Winston, and Howells.

On the optimum end of the spectrum we have the "fast" rod. Owing to larger buttsections, the faster rod more instantly communicates power to outer segments, recovers from less bending, and far more potently recovers from bending -- it has far more authority to do so.

Unfortunately, my first work was influenced by the champions of slower actions and tapers -- who seemed largely to influence general thought. I did not want to build rods which outperformed typical casting skills. But a year or two into this, and largely thanks to Andre Puyans' tremendous guidance, I got straightened out: I built the fastest creatures a caster could handle. Upper tipsections were as fast as .035-.040 thousandths of taper in ten inches. Why so fast? My application showed the way.

As I've explained in loose terms, no one really "knew" how a fly rod should bend during the casting cycle. Understanding physics, there is an ideal. But how do we achieve it? What is this ideal taper for fly casting and linear acceleration?

In order to resolve this question, I built my application.

It has no name really, but I suppose if we are going to refer to it, a handle is conducive to discussion. The last version was written to run on an early Apple II -- and owing to having to operate with 64K blocks of memory by "bank switching" three "chained" (exchanged) program segments -- each of which was named M1, M2, M3, respectively -- let's just call the application "M123."

It happens I'd calculated ballistics since I was 10, and the background was instrumental to solution. What does M123 do, and how does it do it?

Acceleration is the product of force. For instance, the acceleration of gravity, 32 fps/s, is the product of our weight acting on our weight. A force acting on an object of weight W, applied for 1 second, achieves 32 feet per second of velocity. Persistence of this force generates an additional 32 fps of velocity every subsequent second.

Understanding this, we can determine the relative acceleration of a scope of taper designs. How?

Simple really. Given that a casting cycle is initiated with a neutral rodsection exerting zero force, and that a casting cycle culminates at a moment of greatest bending of maximum force, we can divide up the linear acceleration period (LAP) into segments defined by a rodsection intersecting the LAP from the axis of rotation. Each segment of the LAP will be subject to a force relative to the amount of bending in the section.

By adding up the force segments of the LAP, we can determine the relative acceleration attributable then to different bendforms.

Other respects desirable to rod design are determined by recovery. These are largely behavior related. We can also appreciate certain behavior characteristics during the acceleration phase. To render an evaluative expression of performance or behavior attributable to a bendform, an additional scale was developed which further expressed how "nicely" or ideally a rod delivered its incumbent performance attributable to its bending characteristics (essentially rendered by taper and material).

The operation of this rather classic application (in terms of software development) thus centered around undefined "bendforms" which could be physically represented on a display.

The greatest initial innovation beyond realizing we could rate relative acceleration and performance behavior, was the method of acquiring the prospective bendforms. To generate the bendforms, I developed an equation that could deliver any bendform possibly useful to evaluation.

How did the program work then?

A range of arguments is operated on. That is, we input the greatest and least X and Z factors we want to operate upon (bendforms more radical on both ends of the scale of slow and fast, and complex compound, than we would ever want to use can be generated). Another input variable indicates for each of the two principal curve- regulating factors, the size of the increment by which we would step through the range of each -- minimum to maximum. The program then iterates for one X and every Z, and then through the next X and every Z, until combining every possible combination of X and Z throughout the scope/range directed.

Each X and Z combination will generate a specific bendform. At each X-Z combination, the application graphs this bendform as the moment of greatest bending of a casting cycle. It divides the casting cycle up then into so many individual segments defined by a proportion of bending of the same bendform -- with each respective proportion diminishing to zero bending, which defines the beginning and thus the total scope of the casting cycle.

The recoil phase is displayed likewise, demonstrating, from the angle of the axis of rotation, the respective scope and behavior of recoil attributable to the bendform.

The relative force generated over the increasing bending phase of the casting cycle then is appointed to the X-Z pair, as well as evaluative expressions of behavior.

The bendform is also evaluated for proportionately delicate casting cycles -- producing a numeric evaluation of its versatility. Effectively, this further evaluation depicts how similar its delicate casting cycle is to its long-distance cycle and behavior. The nominal expression rewards the design for similarity, because, to the caster, the rod casts the same, forcefully or sweetly, to deliver diverse distance or delicacy. Another factor depicts relative natural breadth of the loop.

As each X-Z combination is graphed, it is paused on the screen for visual evaluation, with its nominal acceleration and behavior evaluations expressed numerically, as well as degrees (total angle) of acceleration, recoil, etc.

So, fifty prospective bendforms, representing actually fine increments of a wholly adequate diversity of taper philosophies, can be evaluated in some 5 seconds each -- or some 4 minutes.

Upon concluding the exploration of taper philosophies, the respective evaluations of each are graphed for each Z and X. Here we see all the data of each hypothetical as compares to the others.

I can hardly convey how insightful the visual and numeric evaluation is. There IS an ideal taper philosophy. It is very fast. To my surprise, it has sort of a hinge in the upper section -- with the outermost tip a bit straighter. Hindsight explains this now, but after some 6 or 9 months spent fervently developing this application, I cannot tell you how instantly and terribly gratifying its results were. Thousands and thousands of hours of mathematic evaluation and development were reduced to seconds.

This much of the application resolves WHAT we are to develop. Now, how do we build it?

To make this part of the story "short," there are substantial breakthroughs required. The logic is not as straightforward as we might assume, because materials have limitations, require different considerations, etc. Garrison offers an engineering method called "moment of inertia." You will note it doesn't even account for angle of incidence or leverage on the bending subsections.

In lieu of non-existent methods, a comprehensive system had to be developed -- taking into account my hollow- building developments, and so forth. The design respects of the application thus deploy the laws of acceleration to deliver a design for any selected bendform, in any material, in any rod length, to cast a given fly line any distance with the attributable behavior.

M123 much as indicates ideal bendform. You simply confirm acceptance of a bendform, input the foregoing arguments of length, line weight and type, and casting distance, and the program designs the hollow-building, does the layout for all my equipment, specifies how to cut the culms, how many good circumferential inches are required, how to split the cane, and even renders essential guide-spacing as determined by segments of bending. All in something like a second.

M123 comes pretty close to divine revelation.

Andre Puyans is a heck of a caster. He knows cane rods and cane rodmakers and design like no one else I know -- aside perhaps from the greatest masters who lay their hands on the wood. He is one of perhaps a half a dozen people to have seen M123. One evening at his shop after a 15-minute demonstration, a bit teary-eyed, Andy said something like, "I learned more in 15 minutes about fly rods and fly casting from that program than I learned in the whole rest of my life."

Reed: Is it currently available, if so on what platforms (Windows 98, 2000, Mac, etc.)? Cost?

Mike: The last version of it ran on an Apple II. My Apple was a very advanced machine for that day, and unfortunately, corrosion or something set in. I can no longer run the machine. I tried about 2 years ago. It's seemingly dead. However my brother Ray, who was an engineer on the Apple II GS, and who is still an engineer at Apple, was able to resurrect the code, and get the application running under an Apple II emulator on a Mac.

He no longer has that setup, but did save the code from the source files, and I still have it. There is substantial difficulty getting it to run, as the ultimate stages of M123 took advantage of exotic hardware (a Mb of RAM) -- which situation no emulator reproduces. I write software for a living now, but we're talking a quarter-million-dollar application here to resurrect M123 to modern OSs from code. If a major financier was interested, I could re-write it for Windows 32-bit. The only justification of such an effort would be production of high-modulus rectangular section design -- which, believe it or not, was my only original intention. I only built cane as a prototype to prove the design.

Reed: Mike, what do you see as the advantages of the rectangular section? **Mike:**I'll just present them roughly, here. The advantages are phenomenal.

MOST of a rod matters little, if a builder is rendering well-distributed, faster tapers. What is critical, is the upper tip-section, and exactly where your compound tapers break off. Missing this juncture by 2 inches, and falling short of ideal proportions there has dramatic consequences.

Why does most of the rod otherwise matter little? Because when you get proper bending, the butt largely just drives the tip -- and the vital bending, necessary to delivering either great power or wonderful delicacy with no vibration and 1-inch loops, largely transpires in a limited segment of the upper tip. The bendform is critical. The challenge is perhaps intimated by the dramatic transformation at a shoulder in the upper rod, below which behavior is largely similar despite the magnitude of work asked from the instrument.

But how do we get this critically defined, dramatic bending in this limited upper section? And where is this area of the rod we should understand so deeply, under which, though "minimal" material is dedicated to the objective, little bending is suffered from what must be delivered to the highly flexible top?

Each part of the upper tip is critical. So let's evaluate the rectangular section against the hexagonal -- or any other regular polygonal section.

A bending member incurs tension on the outside of the bend curve, and compression on the inside. Somewhere between the two opposing extremes of the section in the plane of bending, is a "neutral axis" -- where theoretically no tension or compression is realized. The neutral axis is governed by the tension and compression response intrinsic to the material. That is, if tensile strength is far greater than compression strength (as it is in carbon fiber), the neutral axis moves way over toward the tension side in bending -- tending tremendously to over-stress the weaker compressive side. This is very adverse to deploying the material to the degree commercially promoted by the nominal evaluation, (tensile) "modulus."

We cannot achieve in such a member, suffering reversing cycles of bending, performance proportional to the commercial nomenclature, (tensile) "modulus." Why?

Any material can only withstand so much tension and compression under bending. Dissimilar tensile and compressive properties are deflected so as stresses the weaker property, and so, the ultimate performance of the member is limited by its weakest property multiplied by the disparity between the weaker property and stronger property. Increase tensile modulus, and you cause compressive failure all the sooner.

How does this apply to rectangular versus regular polygonal section design (round, hexagonal, pentagonal, etc.)?

Given we require this focused bending in a limited area of the tip, and given that we want to deploy a maximum section depth to utilize the material most efficiently, we must build the high-performance rod in this area of high necessary bending, with the greatest section depth possible. The material has greater leverage on the neutral axis -- and thus more efficient stiffness -- the greater the section depth.

But given the bending required, we can only build the section so deep, or we exceed unit stress. Regular polygonal sections therefore can only be built "so" deep, or stiff. The greatest section depth possible is a depth, in the plane of bending, which delivers maximum tension or maximum compression under the required bending.

Thus a hexagonal section can only be so stiff as delivered by a section of such depth. Only a rectangular section, built wider, across the plane of bending, can deliver more stiffness. ONLY the rectangular section in fact can be built INFINITELY more stiff, without raising unit stress above tolerable or desirable levels.

How much stiffer is it?

Well, if you have a hexagonal tipsection 50 thousandths deep, and a rectangular section 50 thousandths deep and only 25 thousandths of an inch wider than it is deep, there is a tremendous difference not only in stiffness, but in efficiency.

The hexagonal section has what I call "work-performing flats" which are (from memory) something like .028 inches wide. These opposing flats, separated by the greatest section depth in the plane of bending, incur the greatest stress, and perform by far the greatest amount of work. The rectangular section, able to deliver this same amount of bending, is .075 inches wide. It is 2.67 times as stiff under mere static conditions!

But under dynamic conditions, it enjoys a substantially greater margin of superiority. How?

The neutral, midsection of the cross-section is largely dead weight, along for the ride, and taxing the relative stiffness of the work-performing flats.

The midsection of the hexagonal rod is something like .056 wide; and the relative dynamic efficiency of the stiffness expressed by the proportion of work-performing material to non-contributing mass then is something like .028/.056 = 0.5. The proportion of neutral area on the solid rectangular section then is .075/.075 = 1. The rectangular section, while 2.67 times as stiff, is ALSO twice as efficient. Given this efficiency for 2.67 the degree of stiffness, the solid rectangular section is something like 5 times as stiff under dynamic conditions of casting -- the critical stations of this of course, being the upper section above our vital "shoulder."

Other factors contribute further, such as weight of glue lines. But given that I built tipsections hollow to within less than 10 inches of the very tip -- and removed more weight from tips than previous makers did from buttsections -- and something like 4-5x the weight from buttsections that had been removed previously -- you can understand the performance disparity in faster rods.

[Note: This image is the hollowbuilder]

My construction was hollow like an airplane fuselage -- with some 250 circumferential ribs reinforcing progressively thinner walls along the rodsection.

Reed: Would you give us more on your later rods in terms of their unique tapers?

Mike: Most of the rod served as a very stiff lever to propel the upper section -- with just enough bending down below to move the upper axis of bending through the casting cycle, in a relatively linear, controllable manner. Buttsections were usually simply some .025 to .050 over square, to this upper shoulder.

Above and comprising the upper shoulder, the rod was comprised of dual compound tapers -- differing in the plane of bending and across the plane of bending. Final (uppermost) tapers were incredibly fast.

Reed: How were you able to work at less than 40 thou for tips (the Payne 96 and the Leonard Baby Catskill mike out at .042" and .040" respectively, these were both done on saw bevelers)?

Mike: Yes, but I built steelhead rods with .050 and under tips that would rip a #9 or #10 hi-density shooting head out of the water in one stroke and throw 140 feet of line with one false cast and a huge - 6-inch wet fly. Also consider that at the rate of taper approaching .040 per ten inches, and as I built my rodsections 5 inches longer on both ends before cutting to tip and ferruling length, I actually built many tips that converged to less than .020 in section depth -- comprised of a hugely irregular rectangle of opposing trapezoidal and right-triangular strips.

(Try THAT in a Garrison rod binder, and see what kind of action you get! Any quad builder can tell you binding and glue-up are a nightmare.)

How did I do it?

Buttsections could usually be built of one, straight taper. Tip sections, as processed by the beveller, were another straight taper, to the shoulder. Double-compound tapers, differing in the plane of bending and across the plane of bending, were then produced by HAND SCRAPING, in forms quite different than Garrison's screw-jack contraptions. My forms were precision machined by yours truly in 15-inch segments from precision stock. A divider keeps the strip on each side of the form. The sides are rigidly and fastly bolted together. Shim stock was sometimes used for further taper progress, but double straight compounds proved not only to be adequate, but a more desirable process. With this process I produced perfectly configured and dimensioned right-triangular strips to under ten thousandths of an inch.

I think in this image I may be finishing a hand-planed strip, but this is the essential process. I clamped a strip in place and pulled to the tip with a razor-sharp hand-scraping plate (hand turned after meticulous sharpening). Machine beveled rods only required operation on the top 15 or 20 inches of the rod. The form to the right was a prototype trapezoiding tool which I soon discarded. Come to think of it, from the placement of my tools here, it looks like this picture absolutely must precede my machinery -- but probably by very little.

I still have quite a few of my surplus ends.

They're rather remarkable under magnification. A fellow did a study of classic woodwork at University of California, at Berkeley. He came over to

see me one day, and took quite a few samples. We probably spent half a day or more together, discussing glues, methods, etc. His project was electron microscope photography of glue joints.

He was going to compare my work not only to other rodmakers. He had samples or pieces or something even of Stradivarius' glue lines. He sent me some pictures which were quite incredible, and it turned out his study found my glue lines 3 times tighter than Stradivarius -- who had the second tightest glue lines of the examined history.

By the way, I don't recall the exact figures any longer, but in a whole rod I had less than just a few tenths of a gram of glue. Yet there are perfect microscopic filets in the corners, on the interior of the rod. Gluing was fast and furious -- but a very exacting and painstaking process.

Reed: Of course I would be thrilled to get more pictures of your rods and machinery, especially the "secret beveller". **Mike:**I'm afraid if I don't do an awful lot of work I may lose a huge number of pictures. They need to be digitized.

The beveller was more impressive than you might guess. I still have it, though it has been disassembled and vandalized.

I built from hand-split strips, and, converse to Garrison, would never straighten a strip. I did destruct testing on straightened strips -- produced also by far more gentler processes. They always break like crackers. I can straighten a node without any charring whatsoever, but I would NEVER do that to bamboo. When you consider the flat width in a rectangular buttsection is twice as great as that of a hex section, then you can understand the distance and amount of straightening required to build rectangular out of straightened strips is preclusive. Imagine the sheer placed on the "interlocking" fiber ends -- held together by mere overlapping of bulbous ends. In my opinion, "straighten" a node, and you don't know at all if you've started to slide it apart. But gluing broad, crooked rectangular strips then is almost impossible.

If you look at one of my rods, you'll see the grain follows the strip perfectly, even in the node. So, what my beveller does is allow you to steer down the crooked strip -- even traversing the hump of a node while maintaining tolerances of approximately 3 ten-thousandths.

I have not been to anyone else's shop except Jim Shaaf's once, to pick up some bamboo. He had the Dickerson machine, which he had gotten from Tim Bedford, but I never looked at it, and had long before built my beveller, and was convinced nothing better could be built with conventional cutters of any variety. I'd seen a picture from Dickerson's time, and I think there was stuff stacked all over it anyway.

In any case, I was talking to Scwiebert briefly and Tom Dorsey of Thomas and Thomas at an

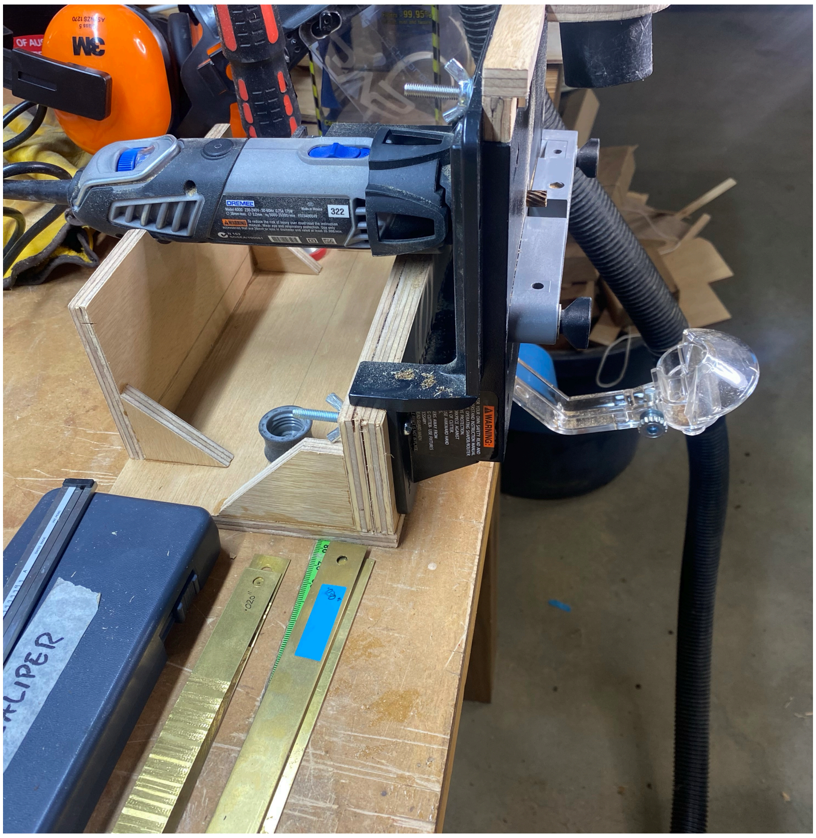
International Sportsman's Exposition. Tom had heard about my secret beveller from who knows who, and Ernie just happened to stop in on us.

Tom asked a whole lot of questions, and eventually asked me then if my beveller was like the Leonard beveller. I didn't know, as I'd done no research at all beyond reading Schwiebert on cane rodmakers. Tom then explained how the Leonard beveller was laid out -- and I answered "no." You can steer a strip through the Leonard beveller -- but not while maintaining accuracy.

My machine was almost silent, nearly dust free. It could handle amazingly convoluted cane with perfect accuracy -- though the job and the setup was certainly fussy. It was fast. It was single pass. There was almost no waste material. And the faces it produced were so perfect, they shined like mirrors. Under magnification, you could see a perfect band of light through the edge of a strip; and you could cut your finger to the bone with the edge of a strip, so little did the cutting process impact the unsupported edges of the material.

6. My Dremel Jig for Scallop & Dam

Horizontally mounted Dremel Router Table with a carving bit



Use shims to set fence depth and do some test strips as below